

An Account of the Malaysian Leucobryaceae (‘lumut puteh’)

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THE MALAY *lumut puteh* (‘white moss’) refers to members of the Leucobryaceae which are exceedingly common in both terrestrial and epiphytic habitats throughout Malaysia. This family was established by Hampe (1837) under the name Leucophaneae, which was changed to Leucobryaceae by Mueller (1843) to accord with the principal genus, *Leucobryum*. It is but poorly represented in temperate regions of the world but well developed in the tropics. In Malaysia there are at least seven genera comprising about thirty-seven species. The family has been regarded as an isolated one (Cardot, 1899) by virtue of the pronounced cellular dimorphism of the anatomical elements of the leaves; or a highly artificial group (Andrews, 1947). The latter author suggests members should be placed partly in the Dicranaceae and partly in the Calymperaceae. In my studies of the Malaysian Leucobryaceae I have inclined to the view that, although related to the Dicranaceae, the Leucobryaceae form a distinct natural group with the exception of the last named genus, *Exodictyon*, which is clearly related to the large but poorly known family, Calymperaceae. Further studies on *Exodictyon* may show it is not a true member of the Leucobryaceae.

The very striking plants referred to this family are almost entirely tropical in distribution with the exception of the temperate *Leucobryum glaucum*. Because of its striking white colour, this species was readily recognized by early botanists. Doody (1696) mentions ‘muscus trichoides montanus albidus fragilis,’ and this plant was figured by Moris (1699). In Dillenius’ catalogue (1719) a moss was described as ‘bryum trichoides, erectis capitulis, albidum fragile’. Linnaeus placed this plant in the all-embracing genus *Bryum*. Legitimate publication for mosses (except Sphagnaceae) begins with Hedwig’s *Species Muscorum* (1801) where it was placed under *Dicranum*. Other bryologists have referred the same species to *Hypnum*, *Fuscina*, *Mnium*, *Oncophorus* and *Sphagnum*. It was not until 1837 that the Leucobryaceae came into their own as a group apart from other mosses.

Morphology and Anatomy

The Leucobryaceae as defined by Brotherus (1924) includes nine genera, seven of which occur in Malaysia. A tenth genus published by Williams (1931) does not occur in Malaysia.

All the Leucobryaceae are characterized by very pronounced cellular dimorphism in the anatomical elements of their leaves. There are at least two layers of leucocysts, with the chlorocysts arranged in longitudinal series between these layers, often with connecting anastomoses. In *Arthrocnemum* and *Exodictyon* the chlorocysts form three layers.

Hedwig, Schwaegrichen and Bridel described *Dicranum glaucum* as lacking a nerve (in Cardot, 1899). This view was followed by many nineteenth century bryologists including Hampe, Mueller, Bruch and Schimper, l'abbé Boulay, Limpricht and Bescherelle. However in other mosses, the lamina of the leaf is only one cell thick and any multi-layered part is regarded as a nerve whether it be sclerified or not. Therefore De Notaris (1869) tentatively put forward the idea that the leaf of the majority of the members of the Leucobryaceae consists almost entirely of a nerve, the lamina being restricted to a small marginal portion which is only one cell thick. This results in two anomalies: (i) the lamina (sensu De Notaris) consists only of leucocysts, dead, colourless cells, while the chlorocysts are confined to the nerve; (ii) in the genus *Leucophanes* there is a central stereid band which runs up the nerve. This must now be called a pseudo-nerve, although in position and function it is more like a true nerve of an ordinary moss. The opinion of De Notaris has been followed by Lindberg, Braithwaite, Dixon, Husnot, Cardot and all other twentieth century bryologists.

In 1899 Cardot published a paper incorporating a very detailed anatomical study of members of the Leucobryaceae. This paper was of such excellence that it seemed to answer all the problems posed by this family, and effectively inhibited research in the first half of the twentieth century. Cardot showed that tribes (and sometimes genera and species) could be separated by the anatomy of the nerve, which he assumed was constant for any one species. He distinguished two basic types of nerve:—(i) *homostrosic* — in which the leucocysts are arranged in two layers at least at the base, (ii) *heterostrosic* — in which the leucocysts were arranged in more than two layers at the base of the nerve. He recognized some intermediate types which he called *sub-homostrosic* (if they more nearly resembled the homostrosic type), and *sub-heterostrosic* (if they more nearly resembled the heterostrosic type). In each case the chlorocysts could be *centric*, *sub-centric* or *hypercentric*.

Following Cardot, the Leucobryaceae may be divided into the following tribes:—

Tribe Leucobryeae

Nerve without a central stereid band. Chlorocysts quadrangular in section, forming a single layer throughout the whole length of the nerve, and situated at the junction of four leucocysts.

1. *Ochrobryum* (homostrosic).
2. *Schistomitrium* (homostrosic, sub-homostrosic or rarely heterostrosic).
3. *Cladopodanthus* (sub-homostrosic).
4. *Leucobryum* (homostrosic or heterostrosic).

Tribe Leucophaneae

Nerve with a central stereid band. Chlorocysts quadrangular in section, forming a single layer over the whole length of the nerve, and situated at the junction of four leucocysts.

5. *Leucophanes* (homostrosic or heterostrosic, distinct border).

Tribe Octoblephareae

Nerve without a central stereid band. Chlorocysts triangular in the upper part of the leaf, situated at the junction of three leucocysts; at the base often quadrangular; forming a single layer the whole length of the nerve.

6. *Cardotia* (heterostrosic or sub-heterostrosic).
7. *Octoblepharum* (heterostrosic).
- *8. *Carinafolium* (heterostrosic, keeled).

Tribe Arthrocormeae

Nerve without a central stereid band. Chlorocysts irregular with 3, 4, 5, 6, or 7 angles and arranged in three layers at least in the upper part of the nerve.

9. *Arthrocormus* (heterostrosic with numerous layers of leucocysts, chlorocysts in a single layer at the base of the leaf, two in the middle part and three above. Border more or less distinct. Chlorocysts never exposed).
10. *Exodictyon* (heterostrosic with numerous layers of leucocysts, chlorocysts nearly always in three layers: a central one consisting of cells with 4, 5, 6, or 7 angles, and a dorsal and a ventral one which are exposed).

Malaysian Leucobryaceae

The following is an account of Malaysian Leucobryaceae which have been studied over the last three years from specimens collected in Malaya and Sarawak, as well as those in the herbaria at the British Museum and Botanic Gardens, Singapore.

* The genus *Carinafolium* was unknown to Cardot.

Leucobryaceae Mueller 1843

Small to large, usually acrocarpous mosses; whitish in appearance due to the presence of a large number of colourless leucocysts. Stem usually branched, bearing rhizoids below. Leaves ascending or secund and made up of two or more layers of leucocysts with small chlorocysts embedded between the layers (exposed in *Exodictyon*). Lamina usually narrow, unistratose and made entirely of leucocysts. Seta erect bearing an upright sub-cylindrical or inclined asymmetrical capsule. Peristome of 8 or 16 teeth, entire or divided half-way into two limbs; or absent (*Ochrobryum*). Operculum rostrate often long-pointed; calyptra cucullate or mitriform.

Key to Genera

1. Leaves with a median band of stereid cells (pseudonerve) 5. *Leucophanes*.
1. Nerve without median band of stereid cells 2.
2. Leaves arranged in three rows 7. *Arthrocnemum*.
2. Leaves not arranged in three rows 3.
3. Leaves closely imbricate, sometimes bearing a long hispid point. Seta often on short lateral branches 3. *Cladopodanthus*.
3. Leaves erect-spreading or falcate, not bearing a long hispid point. Seta terminal 4.
4. Leaves very thick and rigid, consisting mainly of the heterostrophic nerve, chlorocysts in one or three layers, often triangular in section above 5.
4. Leaves not rigid, chlorocysts always in one layer, quadrangular above 6.
5. Teeth eight; leaves thick lingulate, chlorocysts in one layer 6. *Octoblepharum*.
5. Teeth sixteen, leaves thinner with hyaline sheathing base, chlorocysts in three layers 8. *Exodictyon*.
6. Calyptra mitriform, fringed at the base, capsule erect 7.
6. Calyptra cucullate, capsule inclined 4. *Leucobryum*.
7. Seta very short, urn hemispherical, no peristome teeth .. 1. *Ochrobryum*.
7. Seta long, cylindrical, peristome of 16 teeth 2. *Schistomitrium*.

Tribe Leucobryeae

Nerve without a central stereid (pseudo-nerve). Chlorocysts quadrangular in section, forming a single layer throughout the whole length of the nerve, and situated at the junction of four leucocysts.

1. Ochrobryum Mitt., Musc. austr. amer. (1869) 108

Slender plants in lowly, thick, whitish-green to white, lustreless tufts. Erect-spreading leaves, rolled above to form a gutter or pipe, with a long ovate basal part, sometimes with a thorn-tip, sometimes cucullate. *Nerve homostrophic, with leucocysts in two layers at the base. True lamina wide, disappearing at the apex or occasionally replaced by a margin of narrow cells (border)*. Capsule terminal on the stem, immersed, hemispherical in shape. Peristome absent, operculum conical at base with long acuminate tip. Calyptra narrow, conical awl-shaped with thick lashes (fimbriate) at base.

DISTRIBUTION: Sudan, W. Africa, Madagascar, Nepal, Burma, Siam, Malaysia(?) This genus is included by van der Wijk (1958) in his key to Malaysian moss genera. As far as I know no fertile material has ever been found in Malaysia; and it seems doubtful if it occurs here. It is not possible to identify sterile material with any certainty since members of other genera in this family have a similar morphology and some have homostrosic nerves).

Herzog records *Ochrobryum microphyllum* Card. as collected in Perak by Stresemann no. 86 (Dixon, 1926). *Ochrobryum microphyllum* is a South American species and it seems unlikely that it should occur in Malaya. I have not been able to trace this specimen.

A poor specimen labelled *Ochrobryum mitteni* collected by Motley at Toegoe in Java is in the herbarium at the British Museum. It is not fertile and is most probably a *Schistomitrium*. The apex is sub-cucullate with a short apiculus, and the true lamina is four cells wide at the base. The nerve is homostrosic.

2. **Schistomitrium** Doz. et Molk., Musc. ined. Arch. Ind.
(1845-48) 67

Slender to sturdy plants form loose or thick, bluish-green to white, lustreless tufts. Leaves erect-ascending or falcate, lanceolate, either cucullate with a thorn-tip or acuminate. Nerve homostrosic, sub-homostrosic or rarely sub-heterostrosic at base. True lamina wide, never replaced by a border. Seta terminal on stem, long. Capsule exerted, upright, cylindrical. Peristome teeth sixteen, in a disorderly arrangement, finely papillose. Calyptra conical mitriform, long fimbriate.

DISTRIBUTION: Malaysia.

Key to Species of Schistomitrium

1. Tip acuminate, never cucullate 2.
1. Tip sub-cucullate to cucullate with a short thorn-tip 3.
2. Leaves folded over entire length to form a narrow gutter-shaped structure 7. *Sch. mucronatum*.
2. Leaves somewhat concave, flexuose and bent when dry, not forming a gutter-shaped structure 5. *Sch. apiculatum*.
3. Large robust species, leaves at least 5 mm. long 8.
3. Smaller species, leaves less than 5 mm. long 4.
4. Lamina absent or only one cell wide 9. *Sch. sparei*.
4. Lamina at least three cells wide at base 5.
5. Leaves falcate 6.
5. Leaves not falcate, erect ascending 7.
6. Margin entire 3. *Sch. lowii*.
6. Margin serrate 6. *Sch. mucronifolium*.
7. Leaves more or less triangular/lanceolate, strongly cucullate 4. *Sch. nienhuysii*.
7. Leaves ovate, subcucullate with a small mucro-tip 8. *Sch. breviapiculatum*.
8. Border of elongate cells narrow, about 4 cells wide 2. *Sch. subrobustum*.
8. Border of elongate cells broad at base, 6 — 12 cells wide 1. *Sch. robustum*.

1. **Schistomitrium robustum** Doz. et Molk., Bryol Jav. 1 (1845) 21.

Large species forming loose untidy tufts 4 — 7 cm. high, stems dichotomously branched and densely covered by over-lapping leaves. Leaves ascending, oblong/ovate to lanceolate, about 7 mm. long $\times$ 1.5–2.0 mm. wide, secund, concave, distinctly cucullate with a prominent acumen. *True lamina wide at base* consisting of 6—12 rows very narrow prosenchymatous cells, disappearing above. Nerve homostrosic at base of leaf, chlorocysts somewhat hypocentric. Upper leucocyst layer multiplied above to form a bulky sub-trigonal point with chlorocysts strongly hypocentric. Dorsal leucocyst layer not multiplied above. Seta terminal, reddish, 1 cm. high bearing an erect capsule, oblong-cylindrical in shape, striate; operculum subulate-rostrate, about the same length as the capsule. Peristome typical, 16 undivided pale yellow teeth. Calyptra typical, fimbriate, reaching half way down capsule. Spore minutely papillose. (Figure 1; 2 (f)).

PHILIPPINES: Luzon, Infanta, Tayalas; (Robbins 9367).

BORNEO: Liang Gagang; (Verdoorn 17850).

JAVA: ad arb. truncos in Mt. Gegogand near Toegoe 4000; (Burg 489); (Hampe no. loc.); (Bescherelle no. loc.).

2. **Schistomitrium subrobustum** Broth., Leaf. Phil. Bot. 6 (1913) 1976.

Fairly robust plants of whitish green colour, paler or brownish below. Stems 3–6 cm. high, branched. Leaves crowded on the stem, ovate-lanceolate in shape, 5 mm. long $\times$ 1.3 mm. wide, cucullate at apex and abruptly apiculate; nerve broad flat; *lamina four cells wide consisting of an outer row of narrow cells and three inner rows of more or less rectangular cells*, apex may be somewhat scabrous dorsally. Seta terminal erect smooth. (Figure 2 (c)).

Endemic to Philippines.

PHILIPPINES: Luzon, Tayabas Prov., Lucban (Elmer 7414); Infanta (Robinson 9367); Basilan, Entereon (Reillo 16271); Mindanao, Agusan Province, Cabadaran, Mount Urdaneta (Elmer 14111, type).

3. **Schistomitrium lowii** Mitt., J. Linn. Soc. Bot. 22 (1887) 302.

Small to fairly robust plants of yellow green to brownish colour, about 4 cm. high. Leaves *falcato-sekund*, oblong-lanceolate, about 4 $\times$ 1 mm., tip tubular in the apical third of leaf with cucullate apex and a small mucrotip. *True lamina about five cells wide* at the base, consisting of three rows of outer prosenchymatous cells and two rows of inner rectangular cells. Seta brownish about 8 mm. long. Capsule shining, brownish, cylindrical, slightly constricted near the stomium. Calyptra acutely pointed, mitriform, golden below red apex with golden fimbriate hairs. (Figure 2 (d)).

Endemic to Borneo.

BORNEO: Kemoel, W. Koetal (Enderl 4544); Kamborangah (Holtum 25660).

4. **Schistomitrium nienhuisii** Fleisch., Musci Fl. Buitenzorg 1 (1900-1902) 161.

Small to fairly robust plants about 3 cm. high. Leaves crowded, erect-spreading, very concave, *never falcate*, cucullate and abruptly apiculate at apex, triangular to lanceolate, about 5×1.2 mm., tip with a dark golden colour. Lamina with 1-4 rows of small rectangular cells. Nerve homostrosic below with hypocentric chlorocysts. Seta erect, scabrous; peristome teeth pale brown, papillose; operculum conical-rostrate, not quite as long as capsule; calyptra typical, fringed at base. Spores bearing many papillae. (Figure 2 (a); 4).

PHILIPPINES. Luzon, Abra Province (Ramos 7310); Mindoro, Mt. Halcan Merrill 6209).

NEW GUINEA: Idenburg River, 15 m. S.W. Bernhard Camp, 1800 m. (Brass, July 1939).

BORNEO: fide Bartram; Fleischer, Bukit Milie.

MALAYA: Trengganu, Gunong Sembili near Gunong Padang (Hislop, 1952).

5. **Schistomitrium apiculatum** Doz. et Molk., Musc. frond. ined. Arch. Ind. 68 (1846) 24-25.

Syrrhopodon apiculatus Doz. et Molk., Annal. Sc. Nat. 11 (1844) 315.

Schistomitrium strictifolium Dix., ined.*

Small species forming loose to whitish tufts about 2 cm. high. Stems dichotomously branched with leaves frequently forming apical rosettes. Leaves usually *very falcato-secund*, *flexuose and bent over when dry*, 2 mm. $\times$ 0.6 mm., entire, *tip long acute never cucullate*, somewhat concave, ovate-lanceolate with a wide base. True lamina three to four rows of elongate hyaline cells. Nerve homostrosic at base with median or slightly hypocentric chlorocysts. Ventral layers of leucocysts multiplied above to give thick rounded point with strongly hypocentric chlorocysts. Seta short, 1-3 mm. high, smooth or slightly roughened; capsule upright, cylindrical; operculum conical-subulate; calyptra typical, fimbriate, brownish to golden colour completely enclosing capsule.

**Sch. strictifolium* Dix. ined. This specimen (Spare 3543) has an apex which is in all respects similar to other specimens of *Sch. apiculatum*. The leaves are rather long and thin, about 5×0.5 mm. The basal border is three cells wide; the cells being rectangular in shape. The nerve is homostrosic at the base, and heterostrosic near the apex with hypocentric chlorocysts. I see no reason for separating this as a different species. Since the apex is scarcely falcate it could be included below. (Figure 2b).

A very variable species, distinguished from all except *Sch. mucronatum* by its apex which is never cucullate. (Figure 2h, 3).

PHILIPPINES: Luzon, Zambales (Ramos 5152); Rizal, Oriud (Loher 15136) Pangasinan, Umingan (Otaner 18356); Tayabas, Baler (Santos 357); Mindoro, Puerto Galera (Bartlett 13864); Mindanao, Zamboanga Prov. (Merrill 8362).

BORNEO: Bolset, W. Koetai (Endert 2508, 2607a, 4044).

SARAWAK: On fallen tree, Ulu Koyan Oxford Exp. (1932) 2034. On tree in moss forest, Dulit Bridge Oxford Exp. 1932) 1942. Gunong Poe (Beccari (1866)).

SUMATRA: Is. Engano, (Modigliani 787).

JAVA: Mt. Gedah, Tjiburrum, 1700 m. (Fleischer); Pangerango 1700 m. (Kurz); no loc. (Bescherelle).

MALAYA: Pahang, on soil, Sungei Bertam, 1300 m. (Spare 3365); Gunong Jasar (Spare 3543)†; Perak, Lower Camp, Gunong Batu Puteh (Wray 1085); Selangor Border Fraser's Hill, 1300–1450 m. (Burkill et Holttum 8833); Johore, Johore Bahru (Johnson 301).

- 5 (a) ***Sch. apiculatum* var. *copelandii*** (Broth.) Bartram, Phil. J. Sc. 68 63.

Sch. copelandii Broth., Phil. J. Sc. (1908) 13.

Leaves not secund but upright, although flexuose; somewhat longer and more erect-spreading than the type. (Figure 2g).

PHILIPPINES: Luzon, Zambales, Mt. Tapoao, (Ramos 5152). Mindanao, Agusan, (Weber 1297). Zamboanga, 1400 m. (Copeland A.).

SARAWAK: On ground and tree trunk in white sand forest, c. 1000 m., Ulu Koyan, Oxf. Exped. (1932) 1861.

MALAYA: Pahang, Sungei Reriang, Gunong Tahan, on tree in jungle about 1100 m. (Holttum 20847b) (Holttum 20842).

6. ***Schistomitrium mucronifolium*** (C. Muell.) Fleisch., Musci Fl. Buitenzorg 1 (1900–1902) 161 21.

Leucobryum mucronifolium C. Muell., Syn. (1851), 2536 Bryol Jav. (1855) 1 18.

Medium sized species forming very compact neat pale-green pin-cushion like tufts about 4 cm. high and 5–10 cm. across. Stems branched, thickly clothed with overlapping leaves, often in a semi-rosette form at the top of the stem. Leaves falcato-secund, narrowly ovate-lanceolate to lanceolate, concave, *cucullate* with a long golden acuminate tip, lamina narrow consisting of 3–5 rows rectangular cells. Leaves about 6×1 mm., margin serrate above. Nerve homostrosic below with strongly hypocentric chlorocysts. Sporogonium pseudolateral. Seta about 1 cm. high, reddish-golden; capsule cylindrical, upright; operculum long drawn out from a cylindrical base, almost as long as the capsule; calyptra typical, attractive shining golden colour. Figure 1; 2 (e)).

Plants similar to *Sch. apiculatum* but larger and with a cucullate apex.

JAVA: Mt. Salak, 1000 m. (Fleischer (1893)).

MALAYA: Kedah, Kedah Peak, 1000 m. (Holtum 14890, 'forma foliis erectis nec falcatis, seta laeviter rugulosa'), Pahang, Gunong Tahan, 1200–1400 m. (Holtum 20922); Cameron Highlands, rotting wood 1700 m. (Spreng 3420).

7. **Schistomitrium mucronatum** C. Muell. ex Johnson sp. nov.

Species parva; flavo-viride; caespitosa, circa 5 mm. alta. Folia converta, falcata, toto plicata similis canalis tenuim, pauca deflexa. Marginae cellulae 3 ad 4-seriatis, fusiformae, hyalinae. Apex non cucullatus, acutus; cellula terminata flava triangularis. Seta flavo-rubra, circa 6 mm. alta; capsula gracile, cylindrica, erecta. Caetera ignota.

A small plant forming pale yellowish green tufts about 5 mm. high. Leaves closely overlapping, falcate, about 3.5×0.8 mm., folded over entire length to form a shallow gutter-shaped structure, leaf somewhat decurved. Border distinct consisting of three to four rows of narrow prosenchymatous colourless cells. Tip not cucullate but acute, ending in a single yellow triangular shaped cell. Nerve sub-homostrosic below with median chlorocysts; thickened ventrally above. Seta orange about 6 mm. high; capsule slender, cylindrical upright. Operculum and calyptra unknown. (Figure 2 (k), 5).

NEW GUINEA: austro-orient. Brit. in montosis Mo-roka, 1300m. (district Moresby) legit Lamberto Loria, Mueller 1629). TYPE IN B.M. (part of Bryotheca E. Levier).

As far as I know this species has not been described before.

8. **Schistomitrium breviapiculatum** Broth., Oefv. af Finska Vet. Akad. Forh. (1898) 160.

Leucobryum brevisetum C. Muell ms., Brotherus, in Engler & Prantl. 2 ed. 10 (1924) 223.

Small species forming dense tufts 1 cm. high. Stems erect, densely covered with erect or slightly secund leaves, basally concave, long oval, cucullate, obtuse, shortly mucronate, entire, lamina three cells wide. Nerve heterostrosic throughout the leaf. Chlorocysts hypercentric below, hypocentric above. (Figure 2 (j), 5).

Similar to *Sch. apiculatum* but cucullate and more obtuse.

NEW GUINEA: Guilianetti (1897) (fide Brotherus); Mt. Mo-roka (Mueller 743).

9. **Schistomitrium sparei** Dix. ex Johnson sp. nov.

Species caespitosa laxa glauco-viride, circa 1.5 cm. alta. Folia lanceolata, falcata, apice caulorum conferta, magna, 5.4 mm. longa, 0.8 mm. lata, plicata (*Sch. lowii* affinis). Apex cucullatus obtuso-apiculatus. Lamina vera vel nulla vel una cellula seriata.

Loose whitish-blue tufts about 1.5 cm. high. Leaves lanceolate falcato-secund, forming distinct rosettes at the apex of the stem; large, 5.4×0.8 mm., folded (cf. *Sch. lowii*), cucullate, obtuse with apiculate tip. *True lamina absent or only one cell wide*. Fruit unknown. Nerve strongly sub-heterosic at base towards margin's chlorocysts median below hypocentric above. (Figure 2 (i), (6).

MALAYA: Kedah Peak, leaf mould 750m. (Spare 2920). [TYPE].

This species differs from *Sch. lowii* in the narrower, shorter border (true lamina) and the more obtuse leaves. The basal section shows a single, more or less centric layer of quadratic chlorocysts with an increase in the number of leucocysts both dorsally and ventrally towards the leaf margin; a median section shows little increase in the number of leucocyst layers above two; while the apical section shows considerable ventral multiplication.

As far as I know this species has not been described previously.

3. **Cladopodanthus** Doz. et Molk., Musc. ined. Arch.
Ind. (1846) 79.

Vigorous plants forming thick, golden-green, lustreless tufts. Stem upright or creeping. Leaves overlapping, spoon-shaped, usually with a long hair-tip. *Nerve sub-homostrosic. True lamina very wide, never replaced by a border*. Capsule exerted, upright, cylindrical. Peristome teeth sixteen, in a single row, long and thickly lying, finely papillose. Calyptra cucullate, not fimbriate.

DISTRIBUTION: Malaysia.

Key to species of Cladopodanthus.

1. Leaves ending in a terminal hair-point 2.
1. Leaves without hair-point 3.
2. Leaves narrowing suddenly to hair point at least one quarter length of leaf 1. *Cladopodanthus pilifer*.
2. Hair point shorter. Leaves obtuse, strongly concave above
2. *C. speciosus*.
3. Leaves usually truncate when old. Young leaves subtubulose above
3. *C. muticus*.
3. A very small species. Leaves never truncate, usually acuminate to acute
4. *C. microcarptis*.

1. **Cladopodanthus pilifer** Doz. et Molk., Musci Fr. Ined. Arch.
Ind. 3 (1846) 80 28.

Leucobryum cladopodanthus C. Muell., Syn. 1 (1849) 78.

L. piliferum Jaeg., Adumbr. 1 (1871-5) 163.

Robust pale golden-green plants, upright or creeping bearing many short branches covered with dense leaves. Leaves rounded oblong to spathulate, cucullate and suddenly piliferous forming a long hair-like tip, equal to one quarter to one third total length

of leaf. True lamina narrow, only 1–2 cells wide. Nerve sub-homostrosic with hypocentric chlorocysts throughout the whole length of the leaf. Seta 1 cm. high, a little papillose; capsule upright, long cylindrical, brownish red, shining; peristome deeply inserted, 16 teeth some of which may be split half-way and dicranoid; spores smooth. (Figure 7 (a), 8).

BORNEO: Penibukan 1300 and 1500m. (Clemens 5030b and 40531).

JAVA: Herb. Hampe (1881).

MALAYA: Bukit Fraser (Herklots 166a).

1. (a) **var. acuminatus** Doz. et Molk., Musci Fl. Buitenzorg I (1904) 156.

Plant more robust with more crowded branches which stand parallel and erect, leaves somewhat larger but narrower above. (Figure 7 (b)).

JAVA: Mt. Gedeh (Zippelius).

Depak, Batavia (Halle).

2. **Cladopodanthus speciosus** (Doz. et Molk.) Fleisch., Laubmfl. Java. 1 (1900–1902) 156.

Syrrhopodon speciosus Doz. et Molk., Ann. Sci. Nat. (1844) 315.

Spirula speciosa Doz. et Molk., Musci Frond. Ined. Arch. Ind. 72 (1846) 26.

Schistomitrium speciosum Hamp., Bot. Zeit. (1847) 922.

Leucophanes speciosum C. Muell., Syn. 1 (1849) 84.

Plants to 8 cm. high, mostly upright, dichotomously branched. Leaves densely overlapping, julaceous, concave, oblong, cucullate, rounded, about 2×0.8 mm. with a short hair tip usually bent back. Nerve sub-homostrosic similar to *C. pilifer*. Sporophyte terminal on short branches which become lateral by innovation; seta red, about 1 cm. high; capsule upright, long cylindrical; peristome teeth stumpy, mostly undivided. Calyptra mitriform, split once, lobed at the base; spores rough. (Figure 7 (c), (d), 8).

PHILIPPINES: Luzon; Tayabas Prov., Kabatangan Balu, (Santos 228).

CELEBES: B. Watoewila, 1400m. (Fleischer (1899)).

BORNEO: Penibukan c. 2000m. (Clemens 5080).

SARAWAK: Dulit Ridge, mossforest c. 1300m. (Oxford Exp. (1932)).

JAVA: Tjibodas 1400m. (Fleischer (1899)).

M. Prabakti 800m. (Zollinger 3492); M. Salak (Hampe (1881)).

M. Gedeh (Hampe); no loc. (Zollinger 36291).

3. **Cladopodanthus muticus** Broth., Phil. J. Sc. 31 (1926) 279.

Cladopodanthus truncatus Dix., J. Linn. Soc. (Bot.) 50 (1935) 73.

Very branched upright or creeping plants forming tufts 2–3 cm. high and about 5 cm. diameter. Leaves densely overlapping, appressed, erect, oblong, concave, about 2.5×0.5 mm., subtubulose above with a minute apiculus or squarely truncate with apiculus wanting, with margins forming projecting horns. Lamina consisting of elongate cells, two to four cells wide, narrowing above. Seta short; calyptra golden, mitriform, entire, completely covering capsule. (Figure 7 (g)).

PHILIPPINES: Panay, Salibongbong (Martelino et Edano 3578).

BORNEO: (Haviland (1889)).

SARAWAK: Rotten trunk in heath forest under 300m. (Forest Reserve, Marudi (Oxford Exp. (1932))).

4. **Cladopodanthus microcarpus** Dix., J. Linn. Soc. (Bot.) 50 (1935) 74.

A very small species with prostrate or erect branches with densely compacted to somewhat spreading leaves. Leaves erect or slightly secund, rigid, about 2.5×0.5 mm., concave, acute, entire. Capsule small and short, about 0.5 mm. long; calyptra golden, almost entire or slightly notched. (Figure 7 (c) (f)).

This species resembles *Schistomitrium* far more than *Cladopodanthus* in its external form. The leaves are not tightly packed as in other species of *Cladopodanthus*. However the calyptra is typical of this genus not of *Schistomitrium*.

SARAWAK: On a fallen tree trunk c. 800m., Ulu Koyan (Oxford Exp., (1932)).

4. **Leucobryum** Hampe., Linnaea 13 (1839) 42; Brid., Bryol Univ. 1 (1826) 763.

Slender to sturdy plants in thick, bluish-green, whitish green or white tufts, usually lustreless. Leaves ascending when dry, usually falcate, long ovate or lanceolate. Nerve homostrosic or heterostrosic. Lamina generally wide, sometimes completely disappearing at the apex. No distinct border. Seta terminal or lateral, long. Capsule exerted, horizontally inclined, curved, often strumose, longitudinally striated when dry. Peristome teeth 16, each divided half-way to form 32 limbs and dicranoid, transversely barred, thickly papillose. Calyptra cucullate, inflated, entire, never fimbriate.

Distribution: Cosmopolitan but majority of the species are confined to the tropics and sub-tropics.

Key to species of *Leucobryum*.

1. Leaves auriculate at base; nerve homostrosic throughout leaf 2.
1. Leaves not auriculate; usually heterostrosic 3.
2. Leaves falcato-secund; tip scabrous dorsally with serrate margin; true lamina 3-4 rows wide below 1. *L. sanctum*.
2. Leaves erect-spreading; sharply apiculate; tip smooth to slightly scabrous dorsally; true lamina 1-2 rows below 2. *L. subsanctum*.
3. Plant robust. 5 cm. or more tall; leaves large. at least 9 mm. long .. 4.
3. Plants small to medium sized; leaves less than 8.5 mm. long. 5.
4. Leaves tongue-shaped with wavy sides and broad obtuse tip, about 10×1.5 mm.; nerve subhomostrosic with centric chlorocysts
7. *L. cyathifolium*.
4. Leaves lanceolate to ovate with a hollow cucullate to tubular tip .. 6.
5. Silver grey in colour; plant only 4 mm. high; margins of leaf inrolled to base 15. *L. byssaceum*.
5. Green to white in colour; plant more than 1 cm. high; margins of leaf not inrolled to base 7.
6. Very large attractive plants; leaves shining about 16×2.6 mm., base ovate drawn out into a long tubular part above .. 12. *L. pulchrum*.
6. Large loose tufts; leaves dull, lanceolate about 12×2 mm., not drawn out into a long tubular part above, falcato-secund .. 11. *L. javense*.
7. Leaves triangular or ovate in shape; abruptly narrowed and drawn out into a long narrow channelled or tubular part above 8.
7. Leaves lanceolate to ovate; not abruptly narrowed and drawn out above 9.
8. Tip scabrous dorsally 10.
8. Tip smooth dorsally 11.
9. Plants small, under 1 cm. high; leaves triangular, stiff ascending, about 2.5×0.25 mm. 14. *L. microleucophanoides*.
9. Medium sized plants more than 1 cm. high, leaves ovate to lanceolate
12.
10. Leaves erect-ascending, about 8×1.7 mm. 5. *L. scabrum*.
10. Leaves strongly falcate, usually in five rows, about 5×1 mm.
13. *L. candidum*.
11. Silky plants with slender flexuose leaves about 6×0.5 , capsule normal size 6. *L. bowringii*.
11. Not silky; leaves rigid and falcate, about 4×1 mm., capsule very small 8. *L. stenophyllum*.
12. Leaves ovate, about 8 mm. long, rigid with concave base, lamina 12 rows of cells below 3. *L. neilgherrense*.
12. Leaves falcate, only 3 mm. long, lamina 7 rows or less 13.
13. Leaves strongly iridescent when dry, apiculate 4. *L. aduncum*.
13. Leaves not iridescent, tip keeled or cucullate 14.
14. Very rough dorsally with falcate bent over tip, lamina 2-4 rows cells
9. *L. scalare*.
14. Undulate not rough dorsally, tip narrowly keeled, subdenticulate, little falcate; lamina 3-7 rows of cells 10. *L. chlorophyllosum*.

1. **Leucobryum sanctum** (Brid.) Hampe., Linnaea 13 (1839) 42.

Dicranum glaucum var. *sanctum* Brid., Bryol. univ. 1 (1826) 811.

Dicranum sanctum Mees., in Schwaegr., Suppl. 11 (1826) 121 186.

Octoblepharum sanctum Mitt., Proc. Roy. Soc. (1879) 99.

Leucobryum auriculatum C. Muell., Bibl. Bot. (1889) 2.

Leucobryum glaucissimum C. Muell. ined., Dix., J. Linn. Soc. Bot. 43 (1916) 295.

Robust plants forming large tufts to 10 cm. high, covered with large, erect-spreading ovate leaves, usually secund, 7×1.2 mm. Lamina cells in 3–4 rows forming distinct hyaline auricles below. Nerve scabrous on back. Tip serrate due to projections of cell corners. Nerve homostrosic to subhomostrosic, hypocentric chlorocysts at the base becoming centric or hypercentric above. Seta reddish, smooth, 2 cm. long; capsule inclined, strongly strumose longitudinally furrowed, asymmetrical about 1.4 mm. long. Fruit rare. (Figure 9 (d); 10 (a)).

A common species widely recorded from the Philippines, Borneo, Sarawak, Java, Malaya, Singapore, Sumatra, Celebes, Hong Kong, Australia and Samoa.

2. **Leucobryum subsanctum** Broth., Phil. J. Sc. 150 (1907) 339.

Similar to *Leucobryum sanctum* but leaves never secund, always erect-spreading on all sides, sharply apiculate, smooth dorsally. Seta slightly scabrous; capsule suberect, nearly symmetrical or slightly strumose. Figure 9 (c).

PHILIPPINES: Luzon, Bataan Prov., Mt. Mariveles (Merrill 3540; 3549); Upper Lamao River (Williams 843); Tayabas Prov., Baler (Santos 238); Mindoro Prov., Halcon (Merrill 6208); Negros Occid. Prov., Fabrica (Chapman 50).

NEW GUINEA: Moresby District, St. Josephi, secus flumen (Loria 702, type).

MALAYA: Pahang, Gunong Tahan, hanging from tree in mossy wood, 2300m. (Holtum 20900).

3. **Leucobryum neilgherrense** C. Muell., Bot. Zeit. (1854) 556.

Leucobryum triviale C. Muell., Linnaea (1869) 30.

Leucobryum hollianum Doz. et Molk., Bryol. jav. 1 (1855) 17.

Leucobryum textori Besch., Bryol Japan. Supple. 1 18.

Medium sized plants, pale green above, buff-coloured below. Stems 2–3 cm. high, branched. Leaves narrow ovate, 8×0.8 mm., concave base, rigid channelled upper part and minute tip. True lamina twelve cells wide below, rectangular with thin straight unpitted walls; nerve heterostrosic above, not scabrous behind. Seta 2 cm. long, red, smooth; capsule inclined, funnel-shaped at stomium, striate when dry; operculum with rounded base and short blunt tip. (Figure 9 (a)).

A species distinguished by its rigid leaves.

PHILIPPINES: Benguet subprov., Mt. Santa Tomas, trees in fog area (Hadden 113a) Mt. Data 2000m. (Hadden 113).

JAVA: Mt. Gedeh, Tjibodas, 14–1500m. (Fleischer (1899) (1898)).

SARAWAK: Gunong Wah (O. Beccari 32).

CELEBES: Bua Krang c. 2000m. (Fruhstorfer fide Cardot).

MALAYA: Kedah, Inchong Estate, sandy soil (Spare 3008).

4. **Leucobryum aduncum** Doz. et Molk. Bryol. jav. 1 (1855) 319.

Leucobryum brachyphyllum Wils., Jour. Bot. 9 293.

Small to medium-sized plants forming cushion-like tufts. Stems sparingly branched 1–5 cm. high. Leaves shining, iridescent when dry, falcato-secund, about 3×0.5 mm.; tip very rough dorsally, nerve heterostrosic above, homostrosic at base. Seta 2 cm. long, brown, capsule pendulous, strait strumose. (Figure 9 (b); 11).

Widely distributed in the Philippines, Borneo, Sarawak, Java, Sumatra and Malaya. Found also in Ceylon, New Hebrides, Thailand and Hong Kong.

5. **Leucobryum scabrum** Lac., in Miqu., Ann. Musc. bot. Lungdun Batav. 11 292.

A robust species, pale green brown in colour, 2–3 cm. high, forming loose tufts. Leaves large erect ascending, not or very slightly falcate, ovate, upper margins incurved, 8×1.7 mm., lamina five rows, tip very rough dorsally, bent over. Seta 2.5 cm. long, reddish, smooth; capsule pendulous, striate; operculum conical with a long acumen. (Figure 9 (i)).

MALAYA: Kedah, Kedah Peak (Spare 2917, 2902, 2373); Pahang, 1300m. Gunong Terbakar (Spare 3330) (3360); Perak, Maxwell's Hill (Spare 2086, 2132).

Distribution: Hong Kong, Formosa, China, Thailand, Japan.

6. **Leucobryum bowringii** Mitt., Musc. Ind. or. (1859) 26.

Leucobryum angustifolium Wils., Jour. Bot. (Kew Gdns.) 9 (1854) 293.

Leucobryum stellatum Dix. ined.

Medium-sized species with a shining silky appearance, forming compact tufts. Leaves with a narrow elliptical base and long tubulose, acute upper part; 6×0.5 mm., lamina six to nine narrow, thick-walled elongated cells at base, becoming wider at widest part of leaf and denticulate towards tip; not auriculate: nerve heterostrosic above, sub-homostrosic below, chlorocysts hypocentric at base. Seta smooth, red shining, to 2 cm. long; capsule short, squat, strumose at base, striate. (Figure 9 (f), 10 (b)).

PHILIPPINES: widely distributed in Batan, Luzon, Sibuyan and Negros.

JAVA: Mt. Gedah, 1500m. (Fleischer 152).

SUMATRA: East Coast (Bartlett 7 La Rue 227).

MALAYA: Kedah, Kedah Peak (Spare 2779); Inchong Estate (Spare 2931); Perak, Hermitage Hill, 1000m. (Spare 2779); Pahang Sungei Bertam (Spare 3349); Malacca, Mt. Ophir (Ridley 724).

CELEBES: Bua Krang c. 2000m. (fide Cardot).

Distribution: China, Formosa, Japan, Ceylon.

6. (a) var. **sericeum** (Broth.) Dix., Annales Bryologice 5 (1932) 25.

Leucobryum sericeum Broth., Bibl. Bot. (1898) 26.

Leucobryum lousiadum C. Mull. in Micholitz, M. Nov. Guin. no. 139.

Nerve homostrosic above, sub-homostrosic at base. Plant with a very shiny silky appearance. Leaves flexuose, upper half narrow linear, falcate; tip serrate. Lamina 4 cells wide; thin rectangular prosenchymatous cells. (Figure 9 (g)).

PHILIPPINES: widely distributed in Luzon and Bucas Grande Is. and Panay.

NEW GUINEA: Mt. Nok 500–700m., Waigen Is. (Cheesman 106); Tarrara, Warst Kussa River (Brass 8543, fide Bartlett, Farlowia 1 (1943) 44); Milne Bay (Micholitz).

MALAYA: Pahang, Gunong Tahan 2000m. (Haniff et Nur 7973 A); Johore, Gunong Blumut (Holtum 10850).

SUMATRA: Slopes of Dolok Si Patsa-patsa, Tapianoeli (Bartlett 7810).

7. **Leucobryum cyathifolium** Dix., Jour. Linn. Soc. Bot. 45 (1922) 499.

A large robust species similar to *L. javense* in habit, 5–6 cm. high and loosely clothed with large spathulate to lingulate leaves. Individual cells iridescent when dry; whole plant pale green and weakly shining. Leaves 10×1.5 mm. or more, broadly obtuse with a conspicuous wide lamina of 4–8 cells wide; laminal cells rhomboid to rectangular, sometimes curved, internal walls with numerous pores. Nerve subhomostrosic; chlorocysts centric throughout whole leaf. (Figure 9 (e); 10 (e)).

NEW GUINEA: Mt. Durigale nr. Boku, Port Moresby District. (Clark no. 9, type).

MALAYA: Pahang, Gunong Jasar, rotting wood c. 2000m. (Spare 3519).

8. **Leucobryum stenophyllum** Besch., Fl. bryol. Nouv. Caled. (1873) 204.

Leucobryum microcarpum C. Muell. in Engl., Bot. Jahr. (1883) 85.

Leucobryum papuense Par., Ind. (1896) 752.

Leucobryum canocladum Besch. ined. (?), Brotherus in Engler & Prantl. 2 ed. 10 (1924) 224.

Small plants forming loose tufts 1–2 cm. high, densely covered with somewhat tufted leaves, thickly clothing stem; brown to pale green. Leaves small, upright to falcate, asymmetrical, ovate at base, 4×1 ; tip cucullate, somewhat rough, dentate; upper part of leaf tubular. Nerve strongly heterostrosic chlorocysts hypocentric at base, hypercentric above. Lamina 3 cells wide; walls somewhat thickened, smooth, not pitted. Seta 1.3 mm. high; capsule very small, inclined to pendulous, distinct apophysis, striated with an expanded mouth, $0.5-0.8 \times 0.5$ mm. (Figure 9 (j); 10 (c)).

9. ***Leucobryum scalare*** C. Muell., Micholitz, M. Philipp. no. 173.

Large thick cushion-shaped tufts about 15 cm. across and 1–4 cm. high. Stem much-branched, sometimes creeping with side branches (cf. *Cladopodanthus*), brittle. Leaves extremely falcate, usually all turned the same way, often in indistinct rows; shape long ovate, 3×0.7 mm. or slightly larger, concave; apex sharp, tubulose above, serrate, very rough dorsally, often bent over. Lamina very narrow with two to four rows of cells. Nerve heterostrosic. Seta dark, 2–3 cm. long; capsule inclined, barely strumose, furrowed when dry. (Figure 9 (k)).

PHILIPPINES: Luzon, Mt. Balatmejan (Edano 79712); Benguet (Micholitz); Bangui (Sanchez 19); Camaguin de Mindanao Edano (14887).

JAVA: Tjibodas, 1450m. (Fleischer, Musci Arch. Ind. (1901)); Gedeh (Verdoorn 3153); Mt. Salak 610m. (Schiffner 10379); Tdjen Plateau 2000m. (Fleischer 569); Gedah, Tjibodas (Fleischer 568).

BORNEO: Rundum (Balter 220, 216, 214, 22).

MALAYA: Penang, Crag Hill (Binstead 16 and 18); Perak, Bukit Merak (Spare 1459); Hermitage Hill (Spare 2782); Pahang, Cameron Highlands (Spare 3430); Selangor Klang Gates Ridge 300m. (Johnson 303); Johore, Gunong Panti (Johnson 418).

Distribution: Thailand, Burma, Timor.

Leucobryum scalare var. *marchmeyeri* fleisch, Musci Fl. Buitenzorg 1 (1900–1904) 144 and var *tjibodensis* fleisch, ibid 145 are not sufficiently distinct to warrant separation.

10. ***Leucobryum chlorophyllosum*** C. Muell., Syn. 11 535.

Syrrophodon rigidum Duby (non Hook et Grev.) in System. Verz. d. Zoll. Pfl. 3370.

Thick compact matted tufts about 10 cm. across and 1–2 cm. high; stem sparingly branched and thickly leafed. Leaves upright, a little falcate, about 3×0.5 –0.8 mm., narrow ovate with a narrow keeled tip; apex undulate at back and sub-denticulate at tip. Lamina three to seven rows of elongated cells; nerve heterostrosic with hypercentric chlorocysts. Seta red, 2 cm. long; capsule crooked, bent, striated when dry, with an expanded stomium; operculum with a long thin point. (Figure 9 (e)).

NEW GUINEA: Waigeu Is., 1000m. (Cheesman).

CELEBES: Sumbawa (Zollinger 3370, 3770, Warburg).

BORNEO: Rundum (Butler 221, 218).

SUMATRA: Asakan (Bartlett 7554).

MALAYA: Kedah, Somme Estate (Spare 3082); Gunong Bongsu (Spare 2769); Perak, Hermitage Hill (Spare 2769), Lembok Kluang (Spare 3641); Pahang, Cameron Highlands (Spare 3440); Gunong Tahan 1100m. (Robinson 5420).

11. **Leucobryum javense** (Brid.) Mitt., Musci Ind. or., J. Linn. Soc. 1 (1859) 25.

Sphagnum javanense P. Beauv., Prodom. (1805) 88.

Sphagnum javense Schwaegr. Suppl. 11 1 (1823) 4.

Leucobryum falcatum C. Muell. Syn. 1 79.

Large robust plants growing in loose tufts, 6–12 cm. high. Leaves crowded, falcato-secund, lanceolate, apiculate, wrinkled above, upper part hollow cucullate, 12×2 mm. Apex rough dorsally. Nerve heterostrosic above with centric chlorocysts. Lamina four to six row of narrow rectangular cells, outer row linear. Seta 2.5 cm.; capsule short-oblong, inclined, strumose, wrinkled when dry; operculum conic-rostrate. (Figure 9 (n)).

Widely distributed in Philippines, Borneo, Java, Sumatra and Malaya.

Also found in Laos.

12. **Leucobryum pulchrum** Broth. in Mitt., Int. für allg. Bot. (Hamburg) 11 (1928) 3.

Leucobryum sumatranum Broth. ex Dix., Annales Bryologici 5 (1932) 24.

Robust species, similar in habit to *Leucobryum javense* but often even larger, and much more attractive. Leaves loose, shining pale green, about 16×2.6 mm. with an ovate base and a long drawn out tubular upper part which forms three quarters of the total length. Lamina of about ten rows, eight being of arrow rectangular cells and one or two rows larger endohyalocysts. Nerve heterostrosic with chlorocysts becoming hypercentric near the leaf base. Seta about 3 cm. long. Capsule cylindrical, striate with a distinct red annulus. Operculum sharply pointed. (Figure 9 (q)).

Widely distributed in Sumatra, Borneo and Malaya.

13. **Leucobryum candidum** (Schw.) Hk. f. et Wils., Flora N. Zea. 11 (1855) 64.

Dicranum candidum Schw., Suppl. 187.

Leucobryum brachyphyllum Hampe., Linnaea 17 (1843) 317.

Leucobryum pentastichum Doz. et Molk., Bryol. Jav., (1855) 16.

Medium-sized glossy plants about 4 cm. tall. Leaves secund, usually arranged in five rows; baseovate with tubular upper part about one quarter length of leaf, or whole leaf somewhat triangular in form; lamina 4–5 rows of linear cells; size 5×0.8 mm.; tip blunt, scabrous. Nerve subhomostrosic to heterostrosic below.

Distributed in Philippines, Celebes, Borneo, Sarawak and Java; also in New Zealand and Australia.

13. (a) var. **pentastichum** Dix., N. Zea. Inst. Bull. 3 (1923) 95.

Leaves falcate, more or less triangular in shape with a curved tip; very concave at the base. Lamina four rows of thickened cells with distinct pores present.

Leucobryum pentastichum Doz. et Molk., Bryol. Jav. (1855) 16 1.

Leucobryum speirostichum C.M. ms. et nomen.

Leucobryum strictifolium Broth., Oefv. af Finska Vet. Soc. Foerh. 1 v (1898) 159.

Leucobryum Teysmannianum forma Doz. et Molk., Bryol. Jav. 1 17.

NEW GUINEA: Mt. Durigale, nr. Baku, Port Moresby (Clark 7); Main Range (Barton 839).

BORNEO: Penibukan, 1500m. (Clemens 40713b, fide Bartram).

14. **Leucobryum microleucophanoides** Dix. ex Johnson, sp. nov.

Species parva dense caespitosa circa 1 cm. alta, 3 cm. lata, glaucoviride, vix nitida. Folia erecta, non falcata, fere rigida, minuta, circa 2.5 mm. longa, 0.25 mm. lata, triangulo-ovata; apex acuminatus, multi-capillatus. Lamina angusta; marginis cellulae 2-seriatis; externae sub-rectangularae, inflatae; internae lineari-rectangularae. Costa inferna subhomostrostica; superna homostrosica. Fructus ignota.

Small plant forming tight matted tufts just over 1 cm. high and about 3 cm. across, dull whitish-green colour, not much shining. Leaves upright, not falcate and rather stiff, very small about 2.5×0.25 mm., triangularovate with a point pointed tip which usually bears numerous rhizoids. Lamina narrow, consisting of two rows of cells, outer row sub-rectangular and inflated, inner row linear-rectangular. Walls thin, without pores. Nerve subhomostrosic below, homostrosic above. Fruit unknown. (Figure 9 (m), 12).

MALAYA: Kedah, Inchang Estate (Spare 2941) (TYPE); Gunong Bongsu Forest Reserve (Spare 3048, 3070); Perak, Jungle stump 500 m., Hermitage Hill (Spare 2760, 2716); Lembok Kluang (Spare 3642).

15. *Leucobryum byssaceum* C. Muell. ex Johnson sp. nov.

Species minutissima, argento-glaucous; caulis circa 4 mm. altus; Folia anguste-falcata, circa 3 mm. longa, 0.25 mm. lata; marginibus gracilo undulatis involutis ad basin. Marginis cellulae 4-seriatis; 2-externae perlongae angustaeque; 2-internae rectangulares. Costa homostrosica; chlorocystae hypercentricae.

Minute plants about 4 mm. high of a silvery grey colour. Leaves long, falcate, tufted, about 3×0.25 mm.; margin slightly undulate and inrolled right to base of leaf. Lamina four cells wide, two outer narrow linear, two inner rectangular. Nerve homostrosic throughout whole leaf with strongly hypercentric chlorocysts. (Figure 8 (c), 9 (h)).

NEW GUINEA: Mt. Mo-roka 1300 m. (Mueller 703) (TYPE in BRITISH MUSEUM).

Tribe Leucophaneae

Nerve with a central stereid band (pseudo-nerve). Chlorocysts quadrangular in section, forming a single layer over whole length of nerve, and situated at the junction of four leucocysts.

5. *Leucophanes* Hampe. in Flora (1837) 282.

Slender plants in thick whitish shining tufts. Leaves erect-spreading, lanceolate to linear with a central pseudo-nerve of thickened stereid cells. Nerve homostrosic or heterostrosic, often papillose at the tip. Lamina variable and often unequal. Border distinct formed of very wide, sclerified and pluristratified cells in the upper part of the leaf. Seta terminal or lateral; capsule upright, cylindrical, shining, longitudinal streaks often present; peristome teeth sixteen, linear-lanceolate, undivided, somewhat papillose; calyptra cucullate, entire.

Distribution: Tropical.

Key to *Leucophanes* species.

1. Large plants to 6 cm. high 2.
1. Small plants less than 3 cm. high 3.
2. Leaves keeled, at least in the upper part of the leaf 4.
2. Leaves not keeled, flat to slightly concave, falcate
5. *Leucophanes naumannii*.
3. Fine leaved plants; golden yellow-green in colour, leaves drawn out to a long serrate point 4. *Leucophanes sordidum*.
3. Leaves linear-lanceolate; whitish green in colour, not drawn out into a long serrate tip, gemmae may be present
3. *Leucophanes octoblepharoides*.
4. Homostrosic; border extends to apex 1. *Leucophanes candidum*.
4. Heterostrosic; border only in basal half of leaf
2. *Leucophanes albescens*.

1. **Leucophanes candidum** (Hornsch.) Linb., Oefv Vet. Akad. Forh. (1864) 602.

Syrrhopodon candidus Hornsch., Nov. Act. Acad. Leopold. 14 (1826) 701.

Leucophanes reinwardtianum C. Muell., Syn. 1 (1849) 82.

Octoblepharum squarrosus Mitt., Voyag. of Challeng. Admir. Is. 258.

Large conspicuous brownish-green compact tufts to 18 cm. across and 6 cm. high. Leaves crowded, erect, wide-spreading, ovate-lanceolate, about 3.5×0.3 mm., strongly keeled in upper two third of leaf and sharply apiculate; bordered throughout with narrow band of incrassate cells, 3–4 rows wide; nerve homostrophic, with median band of stereid cells, smooth dorsally. Seta 0.8–1 cm. long; slender; capsule erect, cylindrical, warm brown with darker base when ripe; shining; slightly and obliquely striate; operculum rostrate bearing a long hair point, nearly as long as the urn; calyptra cucullate. (Figure 13 (a), 14 (d)).

Widely distributed in Philippines, New Guinea, Borneo, Sarawak, Sumatra, Java and Malaya. Also in Ceylon, Thailand, Fiji and Samoa.

- 1 (a) Var. **densifolium** (Mitt.) Dix., Ann. Bryol. 7 (1934) 23.

Leucophanes densifolium Mitt., Bonplandia (1861) 206.

Octoblepharum densifolium Mitt., Fl. Vit. 387.

Leucobryum candidum var. *aciculare* C. Muell. ined., Dix., Jour. Linn. Soc. Bot. 1 (1935) 76.

Didymodon sphagnoides Hook., C. Muell. im Linnaea 17 (1843) 317, 322.

Didymodon sphagnifolius Hook., Arnott in Nouv. Disp. Meth. (1825) 35.

Arthrocormus hookeri Hpe. Bot. Zeit. (1947) 922.

Syrrhopodon glaucus Schwaeg., Suppl. 2 (1827) 2 tab. 181.

Leucophanes pugioniforme Fleisch. ined., Dixon, Gdns. Bull. 4 (1926) 8.

Leucophanes aciculae C. Muell., ined. Dixon, Gdns. Bull. 4 (1926) 8.

Leucophanes fuscum C. Muell. ined.

Leaves very crowded and adhering together at base. Long excurrent tip. Margin often serrate and sometimes keeled over entire length. (Figure 13 (b)).

Widely distributed in Celebes, Sarawak, Malaya and Indonesian Islands. Also found in Admiralty Islands and Fiji.

2. **Leucophanes albescens** C. Muell., Bot. Zeit. (1864) 347.

Medium sized forming loose tufts to 6 cm. high. Leaves crowded above, erect-spreading, linear-lanceolate, about $2.5-5.0 \times 0.2-0.5$ mm., keeled over the whole length, undulate when dry; apex serrate, teeth sometimes in pairs; nerve with median stereid cells minutely spinulose, heterostrosic, chlorocysts mainly hypercentric. Border extending to half way up leaf consisting of three to five rows of rectangular cells at base, disappearing above. Figure 13 (c).

PHILIPPINES: Luzon, Polillo, Mindanao (Phil. J. Sc. 68 (1939) 72).

CELEBES: Herb. Hampe. (1881), Herb. Besch. (1900).

BORNEO: Sekang, decayed wood (Binstead 73, 74); Sandakan, on tree (Binstead 24).

SARAWAK: Mt. Mulu (Hose 3).

MALAYA: Kedah, Pulau Langkawi (Holttum 17478); Trengganu, on bamboo stump in Kampong, Kuala Trengganu (Holttum 15188); Perak, Kampong Tjok (Spare 3216); Sungei Krian Estate (Spare 2524); Singapore, Pulau Ubin (Fleischer, March 1898).

Distribution: Thailand.

3. **Leucophanes octoblepharoides** Brid., Bryol. Univ. 1 (1826) 763.

Syrrohopodon octoblepharoides Nees., Schwaegr., Suppl. 4 t 311a.

Octoblepharum octoblepharoides Mitt., Voy. Chall. Bot. 111 259.

Leucophanes glaucescens C. Muell., Fleisch., Musci Fl. Buitenzorg 1 (1900-1904) 178.

Leucophanes massartii Ren. et Card., Rev. Bryol. (1896) 99.

Leucophanes minutum C. Muell., Geh. Neue Beitr. z. Moosfl. v. Neu Guin. 2.

Slender delicate plants forming short flattened loose tufts to 2.5 cm. high; leaves flat to shallowly concave above, linear-lanceolate, about 5×0.5 mm., spreading, sometimes slightly expanded at base; border 4-5 cells wide consisting of short thick-walled rectangular cells about 25u wide, continuing to apex, serrulate above, teeth single; apex usually flat, sometimes rounded and expanded and bearing long gemmae; leaf bases quite separate from one another. Nerve heterostrosic below, homostrosic above, chlorocysts usually hypocentric. Seta 4 cm. long, rough, brown; capsule upright, cylindrical, warm-brown when ripe; operculum conical. (Figure 13 (a), 14).

Widely distributed in Philippines, Celebes, Borneo, Sarawak, Sumatra and Malaya. Also in India, Ceylon and Thailand.

3. (a) var. **korthalsii**, Fl. Musci Buitenzorg 1 (1900–1904) 176.

Leucophanes korthalsii Doz. et Molk., M. Frond. ined Archip. Ind. 1846–65.

Small plants to 1.5 cm. high. Leaves more lanceolate and sharply keeled, hyaline teeth on the dorsal side of the leaf-tip.

JAVA: Buitenzorg (Kurz). Distributed in West Java, Sumatra, New Guinea and Admiralty Islands.

4. **Leucophanes sordidum** C. Muell., in Engler, Bot. Jahrb. (1883) 83.

Fine plants with branched stems about 1.2 cm. high, golden yellow-green in colour. Leaves very fine and densely clothing stem, about 3×0.6 , upper part long drawn out and serrate; base ovate, lamina almost obsolete; upper part of leaf keeled. Nerve heterostrosic, leucocysts rather thick-walled with conspicuous pores. (Figure 13 (e)).

NEW GUINEA: Poddy Ins. (Karistock 1888): without locality (Naumann 1878).

5. **Leucophanes naumannii** C. Muell., Engler, Bot. Jahrb. (1883) 83.

Large plant similar to *Leucophanes candidum* in habit, 5 cm. high. Leaves erect-spreading, lanceolate, falcate, about 4×0.5 . Border two cells thick with thickened walls. Nerve heterostrosic with rectangular leucocysts. (Figure 13 (f)).

Confined to New Guinea.

Tribe Octoblephareae

Nerve without central stereid band. Chlorocysts in a single layer throughout the whole length of the nerve; triangular in section in the upper part of the nerve, being placed at the junction of three leucocysts.

6. **Octoblepharum** Hedw., Musc. Frond. 111 (1792) 15.

Sturdy plants forming thick, low, greenish-white to reddish cushions. Leaves erect-ascending with an ovate base and lingulate upper part; very rigid. Nerve heterostrosic with many layers of leucocysts (three to seven at the base; six to eleven in the mid-region and two to four above). True lamina wide at the base, often unequal, disappearing before the tip. Border absent. Seta terminal; capsule upright, regular, oval to cylindrical in shape, peristome teeth eight, each with a median line or sixteen arranged in pairs and without a median line, very rigid; calyptra cucullate, entire.

Distribution: tropical.

1. **Octoblepharum albidum** Hedw., Sp. Musc. (1801) 50.

Octoblepharum cuspidatum C. Muell., Forschungsreise Bot. 57 (nomen), Bartram, Phil. J. Sc. 68 73.

Small to medium sized fragile thick-leaved plants, whitish in colour, slightly iridescent when dry, forming compact cushion-like tufts on soil and on tree trunks. Leaves widely spreading or recurved, oblong to narrow obovate, with rounded apiculate apex. Apical rhizoids may be present. Nerve broad thick, occupying about half the width of the leaf base and three quarters of the upper part, in transverse section showing a single layer of chlorocysts with several layers of leucocysts on dorsal and ventral sides. Lamina cells rectangular, about 30 μ wide, narrower at the margins. Seta 2–3 mm. high; capsule erect, oblong, ovoid; urn 1.5 mm. long; peristome teeth golden colour, eight in number, well spaced from one another; operculum shorter than the urn.

According to Fleischer (1900–1904) this species exists in three forms: (1) *compactor strictor*, (2) *foliis patentibus, demum recurvatis*, (3) *laxior foliis majoribus violaceis*. In the first form the leaves are longer, upright and very densely packed together; while in the second they tend to be shorter, broader, more rounded at the tip and recurved. Some indication of the distribution of the first two forms is given below. It has not been possible to examine specimens of the third form. (Figure 15).

f. *compactor strictor*

PHILIPPINES: Prov. Sorsogon, Mt. Bulusan (Elmer 16473); Luzon, Trosin (Elmer 6673).

NEW GUINEA: Papua Kariosia, low down on tree trunks, sea level (Carr 11478).

BORNEO: Kaung 325 m. near office, downstream on shady side of huge boulder (Dainton 350).

SUMATRA: Tanang Toloe

JAVA: (Hallier 722); Belanger (Herb. E. Bescherelle); Surinam (Herb. Hampe) Buitenzorg 250 m. (Baung 10417); 260 m. (Schiffner 10424).

MALAYA: Gua Panjang, Gua Ninik.

f. *foliis patentibus demum recurvatis*

PHILIPPINES: (Cumming 2211); Dumaguete, Prov. Negros, Is. of Negros (Elmer 10035) (further records see Bartram, Phil. J. Sc. 68, 73).

BORNEO: Sekong, decayed log in the shade (Binstead 69).

JAVA: Buitenzorg (Herb. Hampe); Bogor 300 m. (Kurz 90) (Herb. R. J. Shuttleworth).

MALAYA: Perlis, Telor Jambu (Ridley 245); Penang, The Crag 800 m. (Burkill 747); Head of Waterfall Gardens 100 m. (Burkill 6568); Singapore (Wallich in Herb. Musc. W. Wilson).

Distribution: Cosmopolitan at low altitudes in the tropics although it has been found at 2,000 m. at Kurseong, Sikkim, Himalaya and on oak bark, Beninag-Thall, Kumaon 1,100 m. and Arun Valley, Nepal 2,700 m. (Stanton 1448a). Further distributed in Africa, South America, West Indies, Florida, Mexico, Central America, India, Burma, Queensland and Pacific Islands.

Tribe *Arthrocorneae*

Nerve without a central stereid band. Chlorocysts irregular with 3, 4, 5, 6 or 7 angles and arranged in three layers at least in the upper part of the nerve.

7. *Arthrocormus* Doz. et Molk., Musc. ined. Arch.
Ind. (1845-48) 75.

Slender plants forming thick, whitish shining tufts of considerable diameter; or individual plants found mixed in tufts of other mosses. Leaves arranged strictly in three rows which describe loose spiral round the stem; very brittle and rarely found complete. Nerve heterostrosic with numerous layers of leucocysts (three to five at base; seven to ten at tip). Chlorocysts in a single layer at the base of the leaf; in two layers in the middle part; three above: never exposed (cf. *Exodictyon*). True lamina wide at the base, disappearing towards the tip. Border more or less distinct, forming a unistratified layer of wide cells. Seta terminal or lateral; capsule exerted, upright, long cylindrical; peristome teeth sixteen, very short and stumpy, arranged in pairs, transversely barred and with large warty papillae. Calyptra cucullate, entire.

1. *Arthrocormus schimperi* Doz. et Molk., Musc. fron ined. Arch.
Ind. (1845-48) 76.

Miehlichhoferia schimperi Doz. et Molk., Ann. des Sc. Nat. 2
(1844) 312.

Leucophanes trifarum Hampe ms.

Leucophanes squarrosus Brid., Bryol univ. 1764.

Slender rigid fragile plants sometimes found individually mixed with other plants and sometimes forming immense tufts 2-4 cm. high. Leaves crowded, erect-spreading, very rigid, in three distinct rows which may have a spiral twist, linear, concave, hyaline at the base, usually broken off about half-way down, very convex dorsally. Chlorocysts arranged in three rows about but never exposed. Hyaline lamina cells occupying two-third of leaf base. Seta slender, erect; capsule cylindrical, erect; peristome teeth, short, blunt, papillose, arranged in pairs; operculum conical-rostrate; calyptra cucullate, entire at base. (Figure 16).

Widely distributed in Philippines, New Guinea, Borneo, Sarawak, and Malaya. Also in Queensland, Ceylon, Krakatao, Thailand, New Hebrides and Admiralty Islands.

8. **Exodictyon** Card., Rev., Bryol. (1899) 6.

Slender plants forming thick pale green to whitish, lustreless tufts. Stems upright with numerous rhizoids arising from the leaf axils. Leaves erect-ascending with a sheathing base and a long narrow lanceolate or linear upper portion. Nerve heterostrophic with numerous layers of leucocysts (four to eight). Chlorocysts in three layers, the central layer being formed of cells with 4, 5, 6 or 7 angles; the dorsal and ventral layers being exposed. Seta terminal or lateral. Capsule upright, regular, small. Peristome teeth narrow, lanceolate, sixteen, undivided. Calyptra cucullate entire.

Distribution: Ceylon, Malaysia and Pacific Islands.

1. **Exodictyon sullivanti** (Doz. et Molk.) Fleisch.

Syrrhopodon sullivanti Doz. et Molk., Bryol. Jav. 1 (1856) t. 47.

Octoblepharum hispidulum Mitt., J. Linn. Soc. 10 (1869) 178.

Leucophanes hispidulum C. Muell., Musc. Polynes. (1875) 57.

Syrrhopodon hispidulus Card., Annal. Jard. Bot. Buitenzorg 1 Suppl. (1897) 6.

Trachynotus hispidulus Card., in Sched., Fleisch., Fleisch., Musci Fl. Buitenzorg 1 (1900–1904) 192.

Exodictyon hispidulum Card., Revue Bryol. (1899) 7.

Small plants in loose tufts with conspicuous white leaf-bases, very similar to *Syrrhopodon* in habit. Leaves about 2 mm. long, linear upper portion with clasping base, apiculate apex and spinulose, hispid margins. Hyaline lamina extends nearly to apex. Seta 5 mm. long, slender, orange; capsule upright, cylindrical, orange with a purplish-brown mouth, faintly striate. (Figure 17).

PHILIPPINES: Luzon, Tayabas Prov., Dimasingay, Baler (Santos 355).

JAVA: Mt. Salak 900 m. (Schiffner 39), in forest Tjibodas (Massart (1898)).

MALAYA: Perak, Gunong Semanggol on rotten wood 200–400 m. (Spreng 1726, 1729).

2. **Exodictyon blumii** (C. Muell.) Fleisch., Laubfl. Java 1 (1900–1902) 188.

Slender tufted plants with widely spreading leaves which are long and curved, up to 4×0.15 mm. and usually folded over entire length when dry. Nerve spinulose on both sides to half way up leaf. (Figure 18).

Sidely distributed in the Philippines, Borneo, Java and Malaya.

TAXONOMY AND DISTRIBUTION

1. **Ochrobryum**

This genus is probably not found in Malaysia.

2. **Schistomitrium**

Ten species of *Schistomitrium* occur in Malaysia, two of which have not been described before. *Schistomitrium strictifolium* Dix. ined. (ms. British Museum) is not a distinct species but simply a

longer thinner version of *Sch. apiculatum*. Bartram (1939) considers *Sch. copelandii* is a variety of *Sch. apiculatum*.

—	Philippines	New Guinea	Borneo and Sarawak	Sumatra	Java	Malaya	—
1. <i>Sch. roustum</i>	x	—	x	—	x	—	
2. <i>Sch. subroustum</i> ...	x	—	—	—	—	—	Endemic to Philippines.
3. <i>Sch. lowii</i> ...	—	—	x	—	—	—	Endemic to Borneo.
4. <i>Sch. nienhuisii</i> ...	x	x	.	—	—	x	
5. <i>Sch. apiculatum</i> ...	x	—	x	x	x	x	
var. <i>copelandii</i>	x	—	x	—	—	x	
6. <i>Sch. mucronifolium</i> ...	—	—	—	—	x	x	
7. <i>Sch. mucronatum</i> sp. nov.	—	x	—	—	—	—	Endemic to New Guinea.
8. <i>Sch. breviapiculatum</i> ...	—	x	—	—	—	—	Endemic to New Guinea.
9. <i>Sch. sparei</i> sp. nov. ...	—	—	—	—	—	x	Endemic to Malaya.
10. <i>Sch. heterophyllum</i> * ...	—	x	—	—	—	—	Endemic to New Guinea.

*I have been unable to examine this species.

3. *Cladopodanthus*

There are four species of *Cladopodanthus* in Malaysia, the distribution of which is shown below.

—	Philippines	New Guinea	Borneo and Sarawak	Sumatra	Java	Malaya	Celebes	—
1. <i>C. pilifer</i> ...	—	—	x	—	x	x	—	
var. <i>acuminatus</i>	—	—	—	—	x	—	—	
2. <i>C. speciosus</i> ...	x	—	x	—	x	—	x	
3. <i>C. muticus</i> ...	x	—	x	—	—	—	—	
4. <i>C. microcarpus</i>	—	—	x	—	—	—	—	Endemic to Sarawak.

Cladopodanthus microcarpus resembles *Schistomitrium* in its spreading leaves and external form. But its calyptra is of the typical *Cladopodanthus* type, cucullate and without fimbriate hairs.

4. *Leucobryum*

There are at least fifteen species of *Leucobryum* in Malaysia. There has been a superfluity of new species proposed for this genus and it has been found necessary to submerge several where the features shown were not sufficiently distinct to warrant specific separation. It has been found necessary to describe two new species used in manuscript by Dixon and Mueller. In the table below nine of the fifteen species found outside Malaysia are indicated(*).

	Philippines	New Guinea	Borneo and Sarawak	Sumatra	Java	Malaya	Celebes	
1. <i>L. sanctum</i> * ...	x	x	x	x	x	x	x	Found in from Nepal to Samoa.
2. <i>L. subsanctum</i>	x	x	—	—	—	x	—	
3. <i>L. neilgherrense</i> * ...	x	—	x	—	x	x	x	Found in Ceylon, Tientsin, Japan and Korea.
4. <i>L. aduncum</i> *	x	—	x	x	x	x	—	Found in Ceylon, New Hebrides, Thailand and Hong Kong.
5. <i>L. scabrum</i> * ...	—	—	—	—	—	x	—	Found in Hong Kong, China, Formosa, Thailand and Japan.
6. <i>L. bowringii</i> *	x	—	—	x	x	x	x	Found in China, Formosa, Japan and Ceylon.
(a) var <i>sericeum</i>	x	x	—	x	—	x	—	
7. <i>L. cyathifolium</i>	—	x	—	—	—	—	x	
8. <i>L. stenophyllum</i> ...	—	x	x	—	—	—	—	
9. <i>L. scalare</i> * ...	x	—	x	—	x	—	x	Found in Thailand, Burma and Timor.
10. <i>L. chorophyllosum</i> * ...	—	x	x	x	x	x	x	Found in Ceylon, Sumbawa, and Timor.
11. <i>L. javense</i> * ...	x	—	x	x	x	x	x	Found in Laos.
12. <i>L. pulchrum</i> ...	—	—	x	x	—	—	x	
13. <i>L. candidum</i> *	x	—	x	—	x	—	x	Found in New Zealand and Australia.
var. <i>pentastichum</i> ...	—	x	x	—	—	—	—	
14. <i>L. microleucophanoides</i> sp. nev. ...	—	—	—	—	—	x	—	Endemic to Malaya.
15. <i>L. byssaceum</i> sp. nov. ...	—	x	—	—	—	—	—	Endemic to New Guinea.

5. *Leucophanes*

The various species described from Malaysia have been reduced to five. *Leucophanes densifolium* Mitt. is regarded as a variety of *Leucophanes candidum* (Hansch.) Linb. This variety has been referred to under many synonyms. It is not considered that *Leucophanes aciculare* C. Muell. and *Leucophanes pugioneforme*. Fleisch. are distinct species. Further, no distinction is made of *Leucophanes massattii* and *Leucophanes minutum* which are considered to belong to *Leucophanes octoblepharoides*.

—	Philippines	New Guinea	Borneo and Sarawak	Sumatra	Java	Malaya	Celebes	—
1. <i>Leucophanes candidum</i> * ...	x	x	x	x	x	x	—	Found in Ceylon, Thailand, Fiji and Samoa.
var. <i>densifolium</i> ...	—	—	x	x	x	x	x	
2. <i>Leucophanes albescens</i> ...	x	x	x	—	—	x	x	Found in Thailand.
3. <i>Leucophanes octoblepharoides</i> ...	x	x	x	x	x	x	x	Found in India, Ceylon, Thailand.
4. <i>Leucophanes sordicum</i> ...	—	x	—	—	—	—	—	Endemic to New Guinea.
5. <i>Leucophanes naumanni</i> ...	—	x	—	—	—	—	—	Endemic to New Guinea.

6. *Octoblepharum*

Octoblepharum albidum is a cosmopolitan species, usually found at low altitudes in the tropics, although it has been found at 2,000m. in the Himalayas and on oak bark in Nepal at 2,500m. It is found throughout Malaysia, in Africa, S. America, West Indies, Central America, Burma, India, Queensland and the Pacific Islands. The soft form, previously called *O. cuspidatum*, is considered by Bartram to be inseparable from *O. albidum*, of which it is probably a shade form.

7. *Arthrocorpus*

Arthrocorpus schimperi is widely distributed through Malaysia and is also found in Ceylon, Queensland, Krakatao, Siam, New Hebrides and the Admiralty Islands.

8. Exodictyon

Exodictyon sullivantii is found in the Philippines, Java and Malaya; while *Exodictyon blumii* is found in the Philippines, Borneo, Java, Malaya and also in India and Pacific Islands.

Other species recorded from Malaysia include *E. subdentatum* (Broth.) Card.; *E. arthrochromoides* (C. Muell.) Card., *E. giulanetti* Broth. and *E. subscabrum* (Broth.) Card. None of these appear to be common.

PHYLOGENY

Owing to the pronounced cellular dimorphism of the anatomical elements of their leaves, the Leucobryaceae were compared with *Sphagnum*. There are, however, several important differences:— (a) the leaves of *Sphagnum* are uniformly one cell thick, the hyaline cells and chlorocysts being arranged in a net-work, not in layers as in the Leucobryaceae; (b) these cells have an entirely different origin in the two groups; (c) the structure of the hyaline cells of *Sphagnum* differs from that of leucocysts in several particulars. In *Sphagnum* the hyaline cells usually have annular or spiral false partitions, and their walls are perforated by specially constructed pores with raised borders. In the Leucobryaceae the leucocysts are simply dead thin-walled cells with simple pores formed by resorption of the cell-wall. A comparison of the mode of branching, the anatomy of the stem and the features of the sporophyte show there is very little true relationship between these two groups of plants.

Leucobryum is the only genus found in Europe and North America. Its manner of growth, branching, falcate leaves and dicranoid peristome is very similar in organization to *Dicranum*. However in the majority of species of *Dicranum* the nerve is devoid of chloroplasts consisting of two layers of stereid cells separated by a median arc of colourless *eurycists*. The cells of the lamina are green. However in three species of *Dicranum* the structure of the nerve has been compared with that of *Leucobryum*. In *Dicranum albicans* the nerve is three-layered consisting of a dorsal and a ventral layer of empty hyaline cells, and between these a layer of green chlorocysts. These chlorocysts are not situated at the points of junction of the empty cells but form a continuous layer. This type of anatomical organisation has also been found at the extreme base of the leaf in some species of *Leucobryum*. *Dicranum longifolium* and *D. sauteri* have a similar organisation but there is some tangential division of the colourless cells on the dorsal side. The true lamina is also much wider in these species, and like all *Dicranum* spp. is, of course, green.

In other Dicranaceae e.g. *Campylopus leanus* and *Brothera japonica*, there are two layers of empty hyaline cells and between these there is an admixture of non-chlorophyll containing cells plus scattered stereids. The true lamina is green but very narrow.

In many Calymperaceae and Syrrhopodontaceae the lower portion of the lamina (sheath) consists of colourless cells. In *Leucophanella* the lamina is almost entirely formed of hyaline cells the green portion consisting of only two rows of square cells above. It is very difficult to distinguish members of this genus from *Leucophanes* once they have been dried. In *Syrrhopodon tristichus* the nerve has three layers of chlorocysts surrounded by stereids. The lower lamina is colourless. *Syrrhopodon* and *Exodictyon* approach one another in their leaf form.

According to Andrews (1947) the genus *Leucobryum* should be included in the Dicranaceae. Its sporophyte, calyptra, capsule and peristome are typically dicranoid. Its peculiar leaf is regarded as specialisation of the nerve only, further development of the complicated nerve met in *Paraleucobryum*, *Brothera* and *Gampylopus*.

The tropical Leucobryaceae, apart from *Leucobryum*, are not a bit like *Dicranum*. Their sporophyte, calyptra and peristome are variable, and the latter is not truly dicranoid in any other genus. The Leucobryaceae are very distinct from the Dicranaceae in a number of important particulars, not least of these being that the lamina in the former consists of colourless dead cells, while in the latter they are always green. *Leucophanes* and *Exodictyon* are very similar to the Syrrhopodontaceae. Encroachment of the colourless sheath to include all the lamina would result in a transition from the Syrrhopodon type to the Leucophanes/Exodictyon type. The single row of papillose peristome teeth are shared by these genera and Syrrhopodon.

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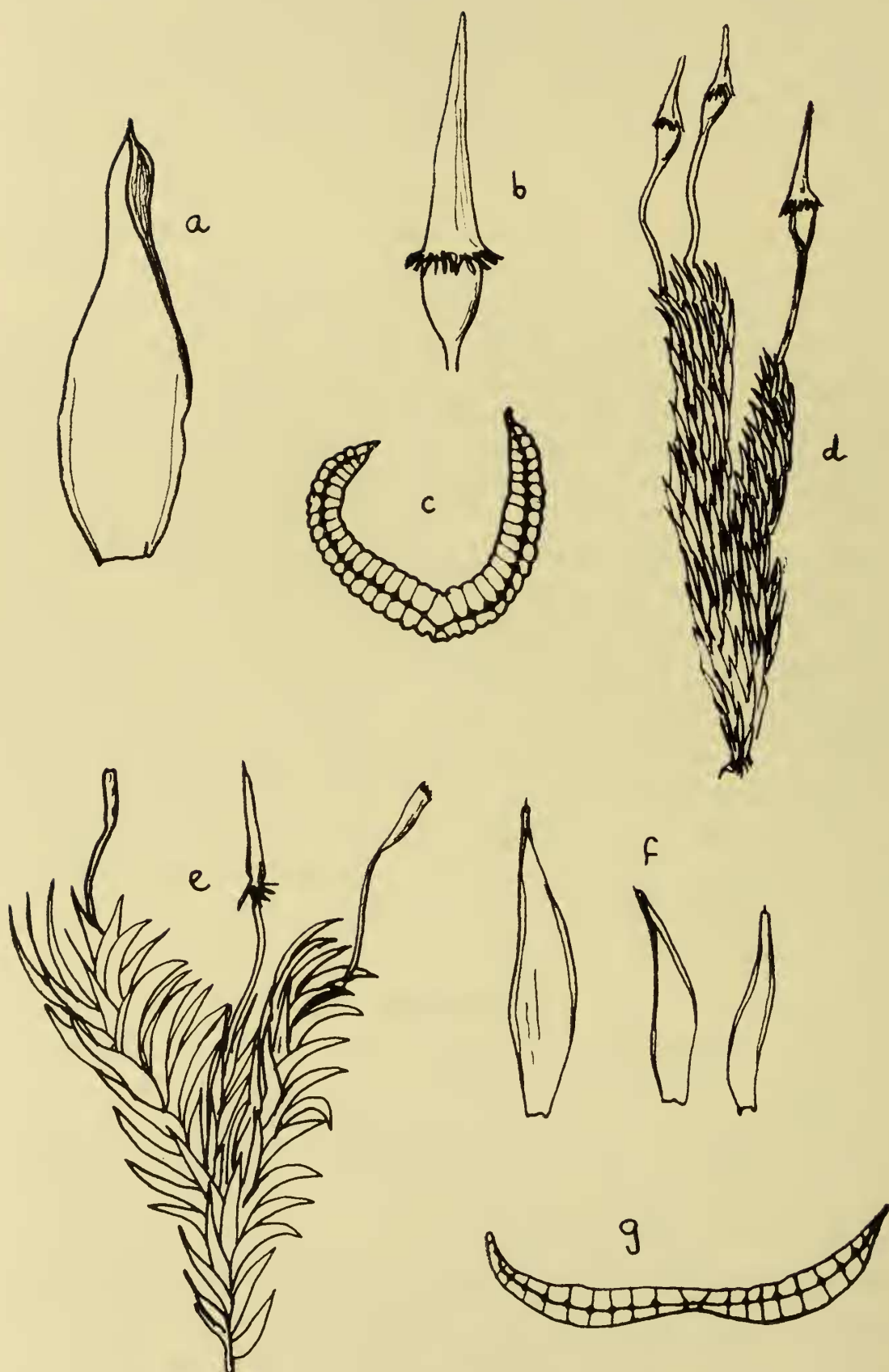


Figure 1. *Schistomitrium robustum* (a) leaf (x 7) (b) capsule (x 5) (c) t.s leaf (x 30) (d) whole plant (x 1).

Schistomitrium mucronifolium (e) whole plant (x 1.5); (f) leaves (x 6) (g) t.s. leaf (x 50).

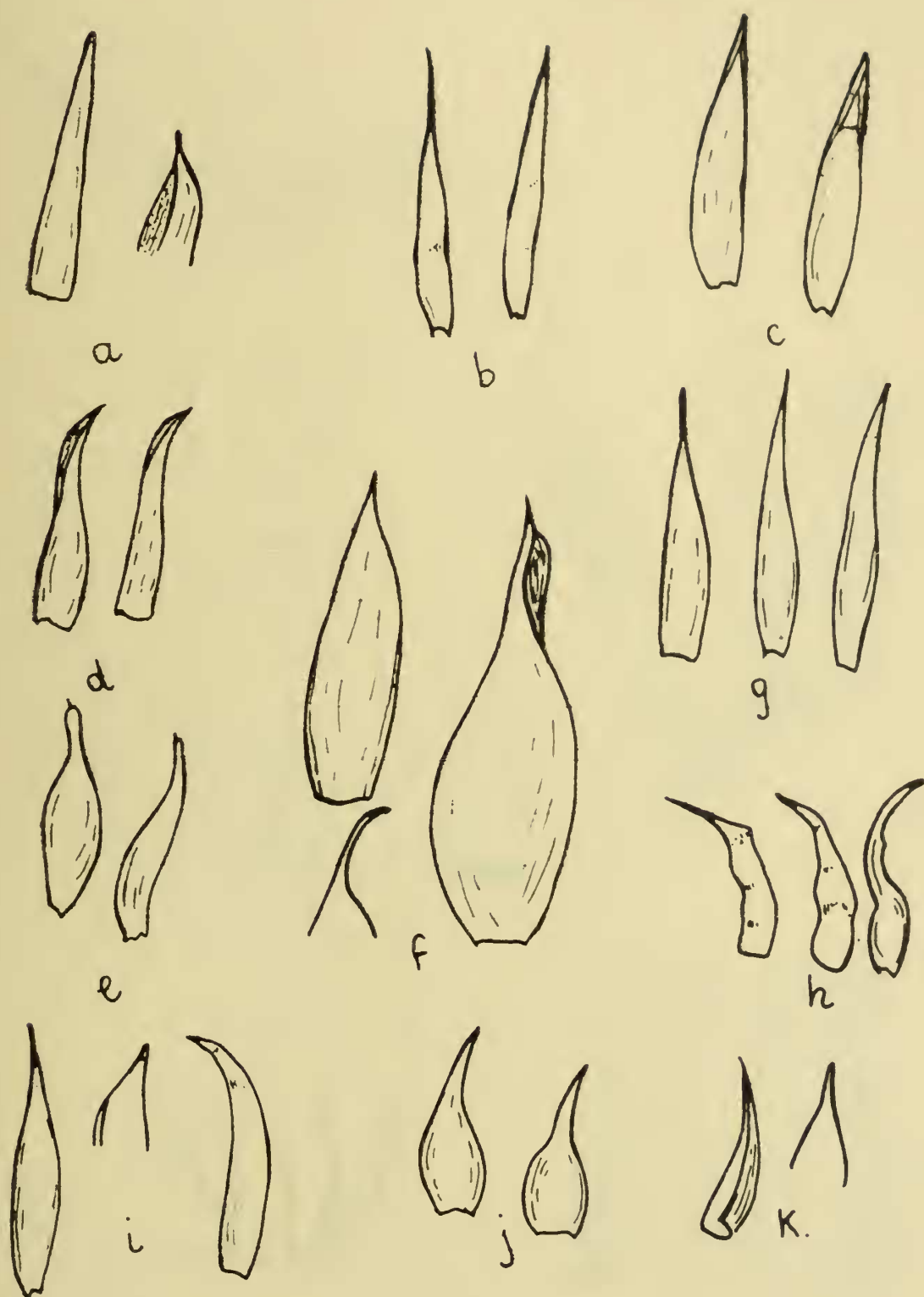


Figure 2. *Schistomitrium* species (x 7).

- | | |
|---|---|
| (a) <i>Sch. nienhuisii</i> . | (b) <i>Sch. apiculatum</i> var. <i>copelandii</i> (f.). |
| (c) <i>Sch. subrobustum</i> . | (d) <i>Sch. lowii</i> . |
| (e) <i>Sch. mucronifolium</i> . | (f) <i>Sch. robustum</i> . |
| (g) <i>Sch. apiculatum</i> var. <i>copelandii</i> . | (i) <i>Sch. sparei</i> . |
| (h) <i>Schistomitrium apiculatum</i> . | (j) <i>Sch. breviapiculatum</i> . |
| (i) <i>Sch. mucronatum</i> . | |

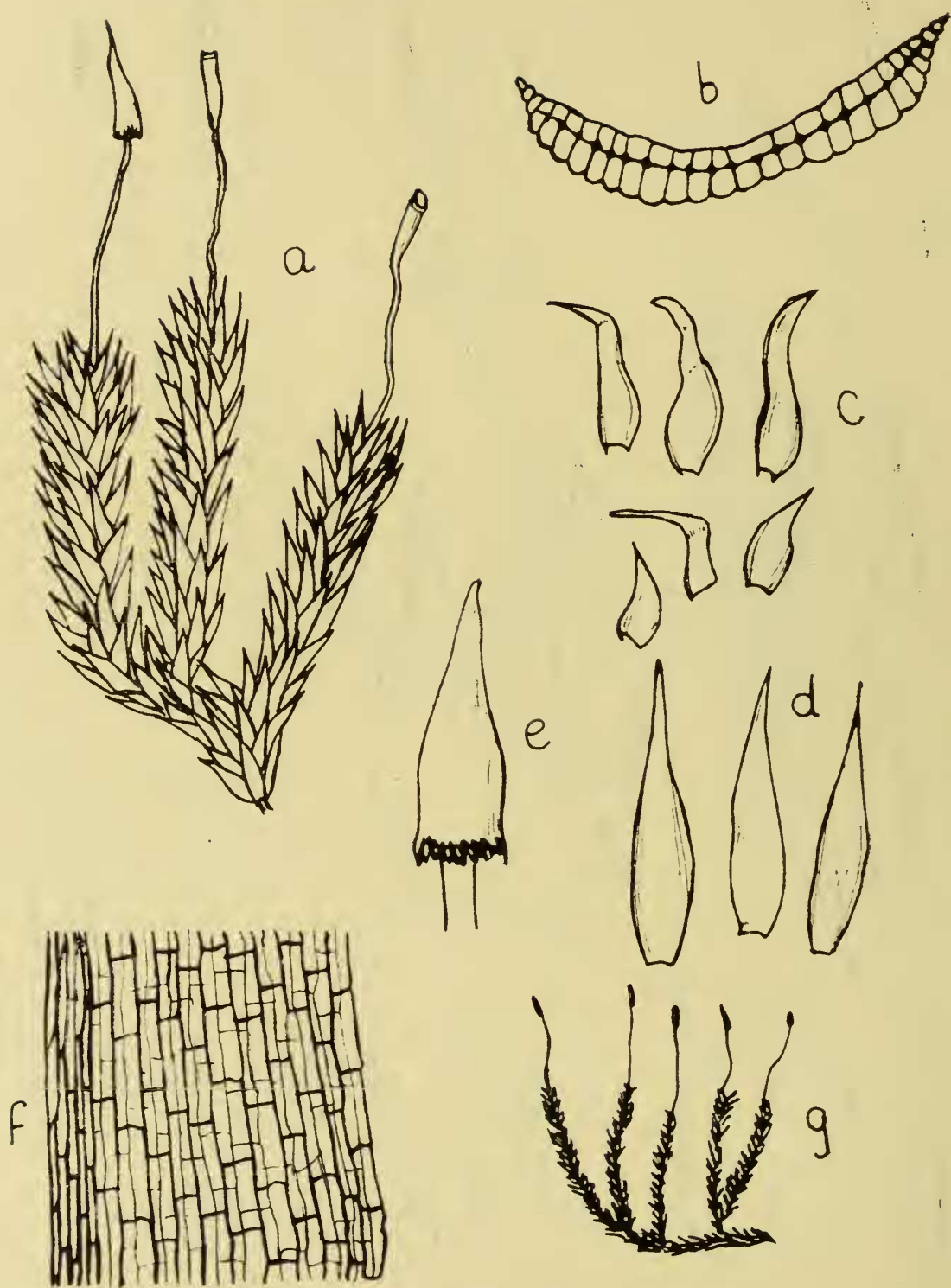


Figure 3. *Schistomitrium apiculatum*.

- (a) whole plant (x 2.5).
- (b) transverse section of the leaf (x 100).
- (c) leaves (x 7).
- (d) var. *copelandii* leaves (x 7).
- (e) capsule (x 7).
- (f) leaf border (x 100).
- (g) habit (x 1).



Figure 4. *Schistomitrium niewenhuisii*, transverse section of leaf (x 100).



Figure 5. (above) *Schistomitrium breviapiculatum*; (below) *S. mucronatum* transverse sections of leaves (x 100).

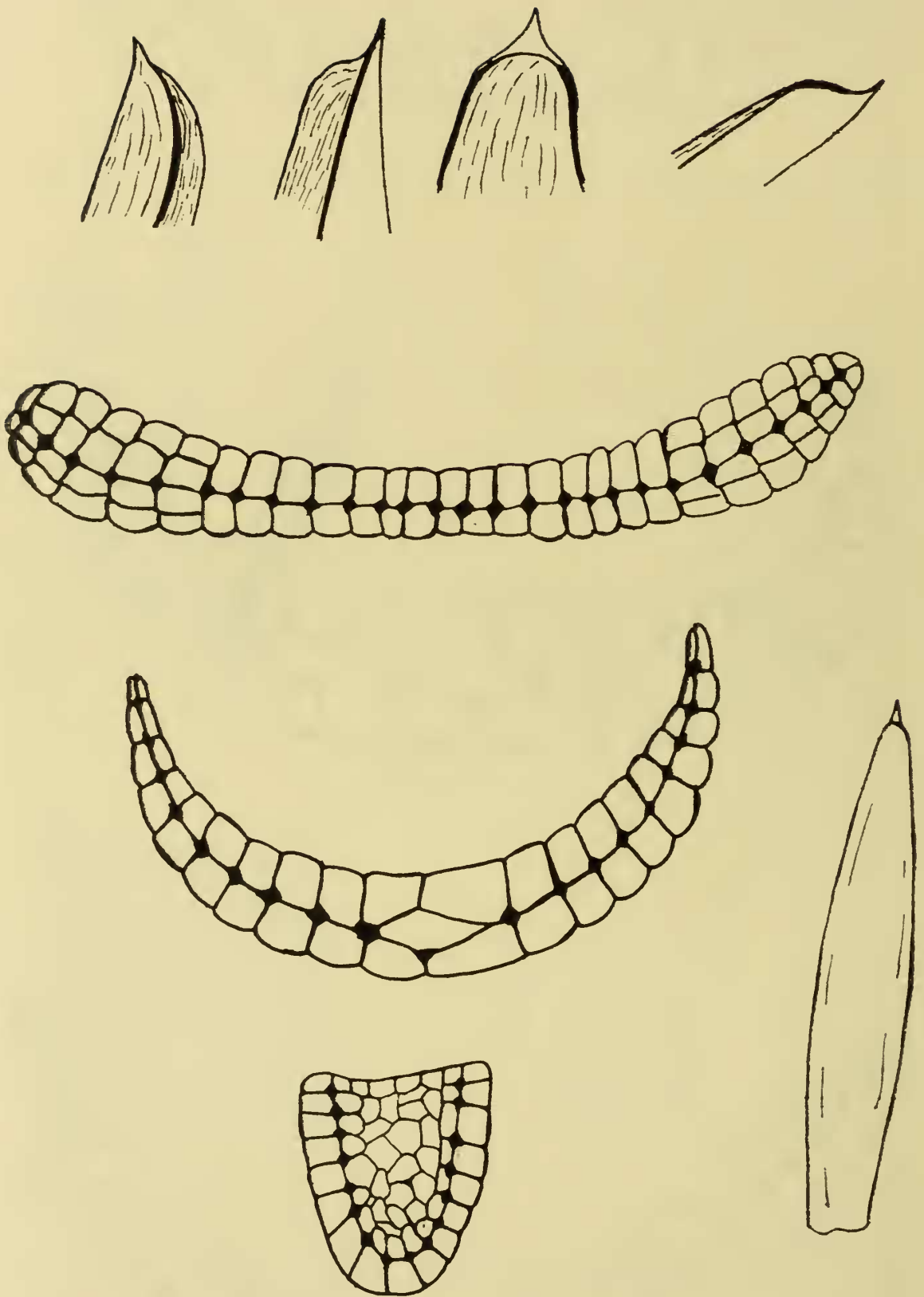


Figure 6. *Schistomitrium sparei* (above) details of apex (x 20); transverse section of base and of mid-leaf (x 125); (right) whole leaf (x 10).

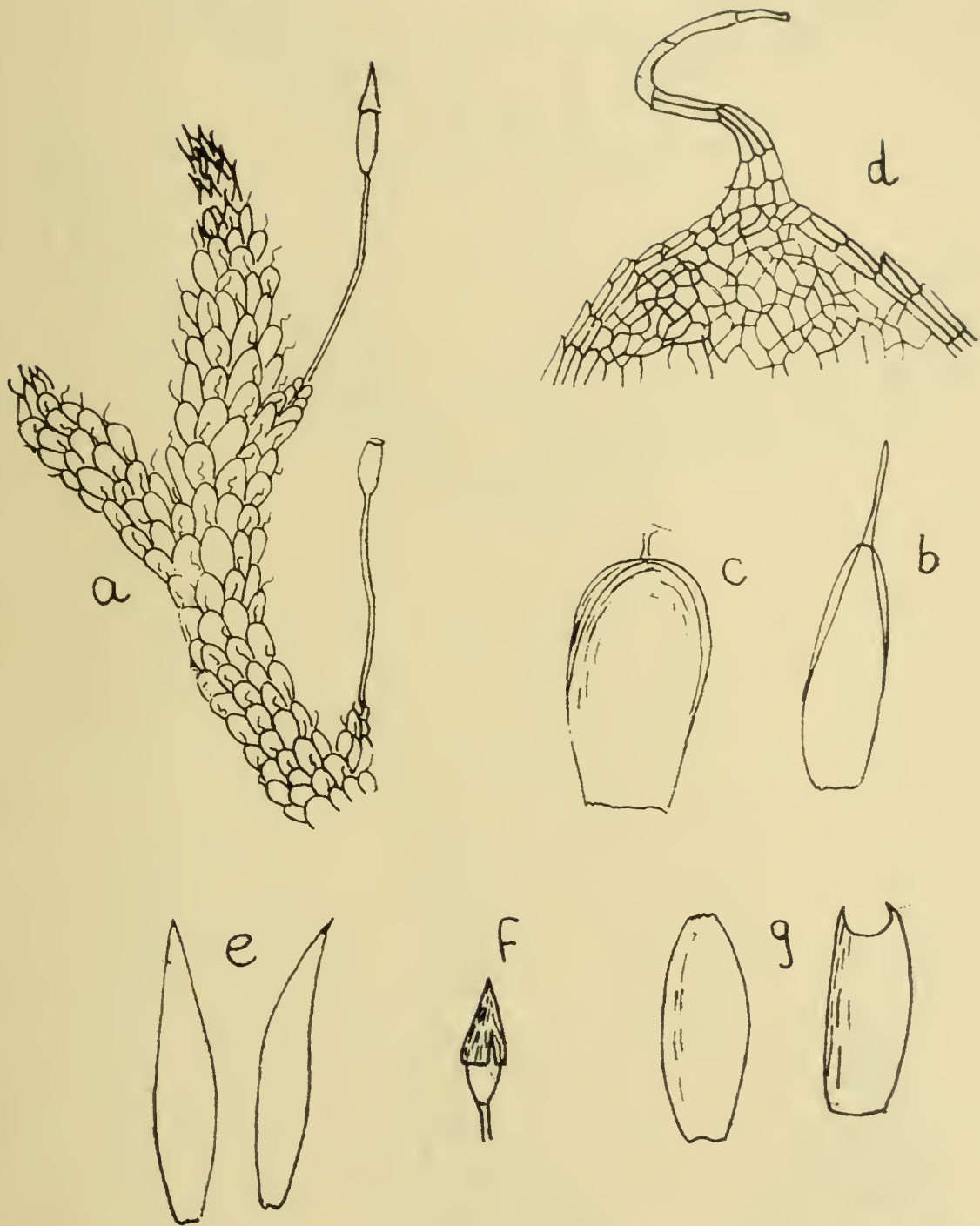


Figure 7. (a) *Cladopodanthus pilifer* branch (x 1.5), (b) var. *acuminatus* leaf (x 12), (c) *Cladopodanthus speciosus* leaf (x 12), (d) detail of apex of (c) (x 50), (e) *Cladopodanthus microcarpus* leaf (x 12), (f) capsule (x 1.5), (g) *C. muticus* (x 12).

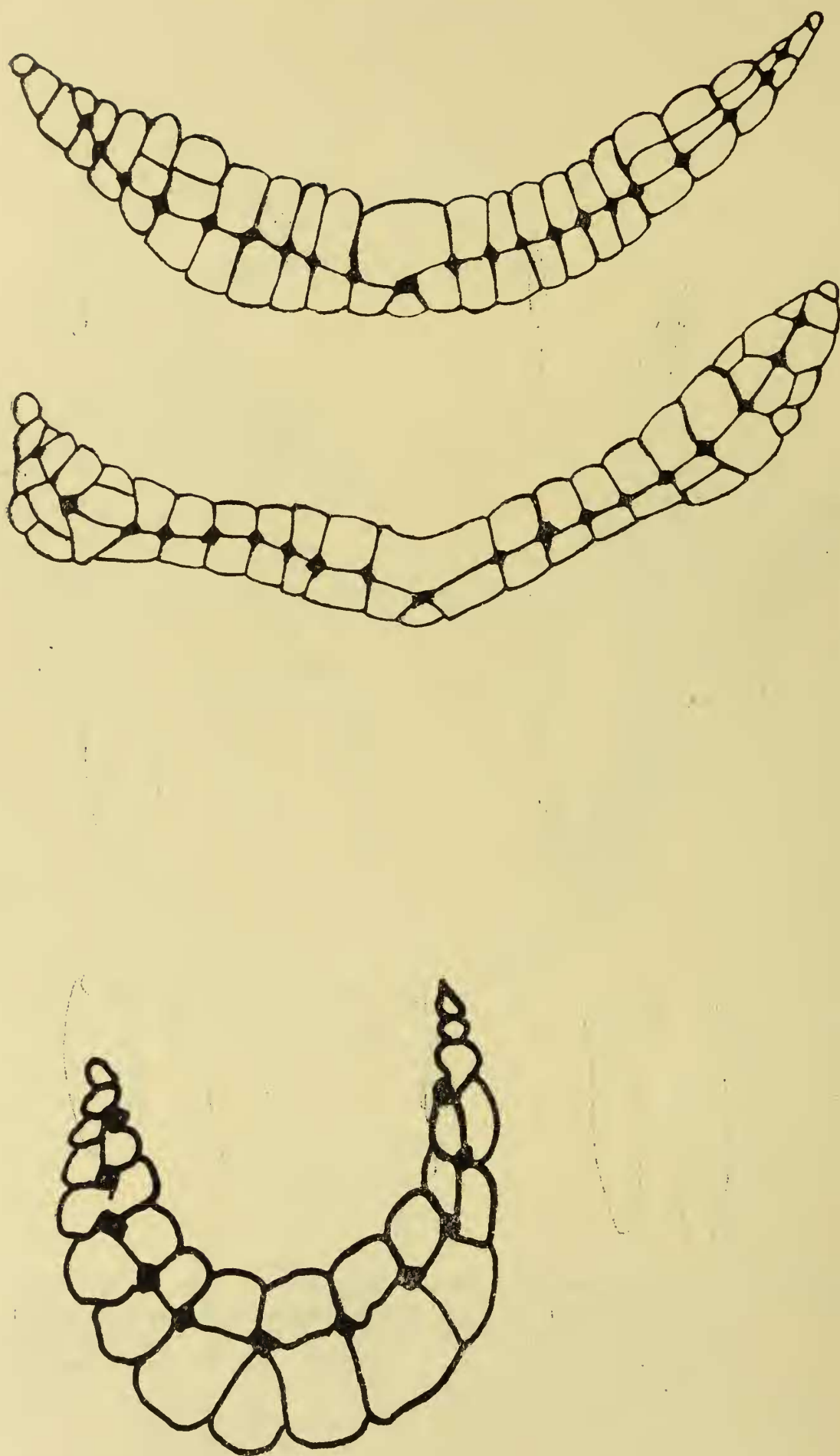


Figure 8. Transverses sections of leaves (x 140).

Cladopodanthus pilifer (above); *Cladopodanthus speciosus*
(centre) *Leucobryum byssaceus* (below).

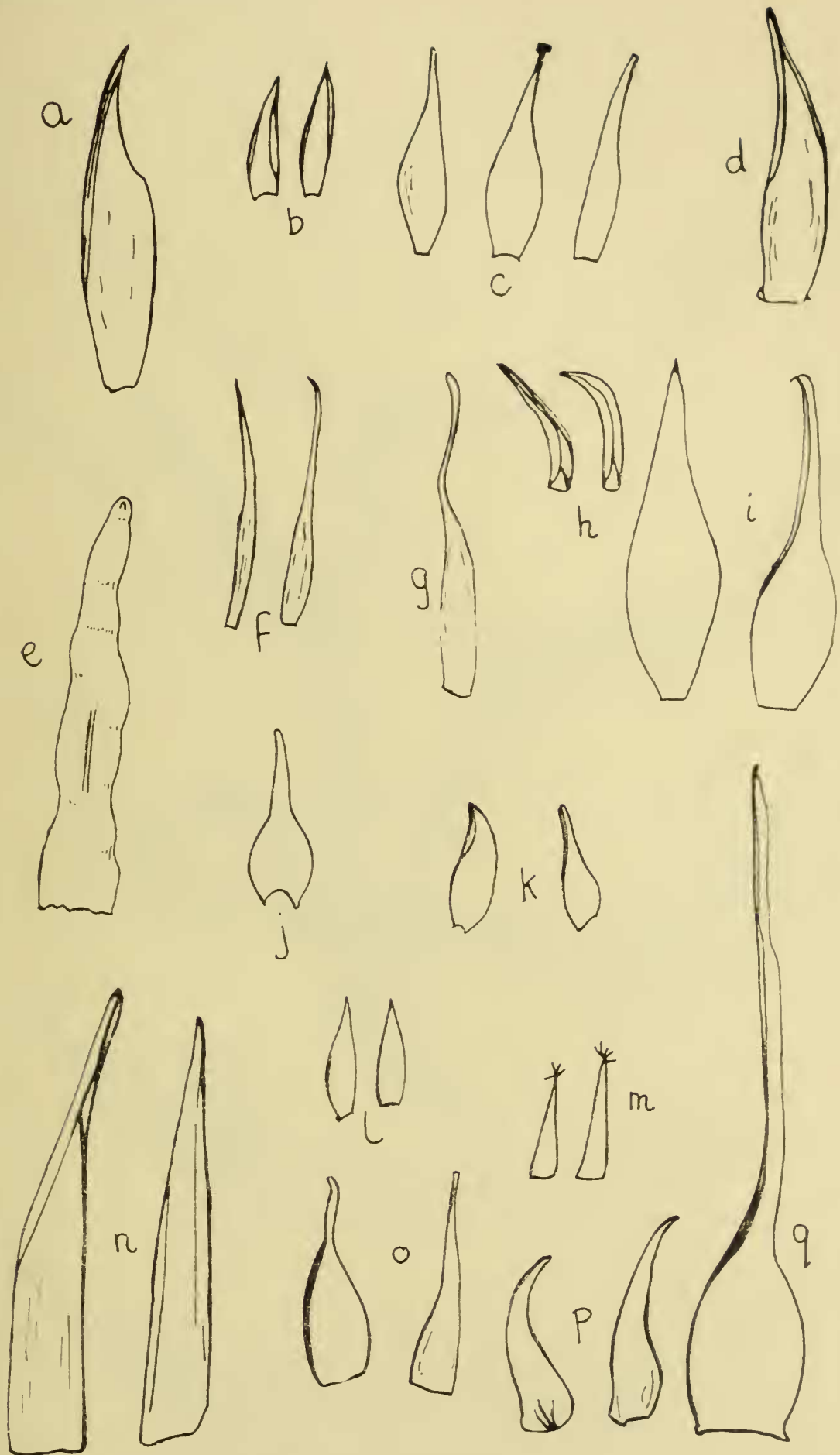


Figure 9. Leaves of *Leucobryum* species (x 5):—

- | | |
|--|---|
| (a) <i>L. neilgherrense</i> . | (b) <i>L. aduncum</i> . |
| (c) <i>L. subsanctum</i> . | (d) <i>L. sanctum</i> . |
| (e) <i>L. cyathifolium</i> . | (f) <i>L. bowringii</i> . |
| (g) <i>L. bowringii</i> var. <i>sericeum</i> . | (h) <i>L. byssaceum</i> . |
| (i) <i>L. scabrum</i> . | (j) <i>L. stenophyllum</i> . |
| (k) <i>L. scalare</i> . | (l) <i>L. chlorophyllosum</i> . |
| (m) <i>L. microleucophanoides</i> . | (n) <i>L. javense</i> . |
| (o) <i>L. candidum</i> . | (p) <i>L. candidum</i> var. <i>speiostichum</i> . |
| (q) <i>L. pulchrum</i> . | |

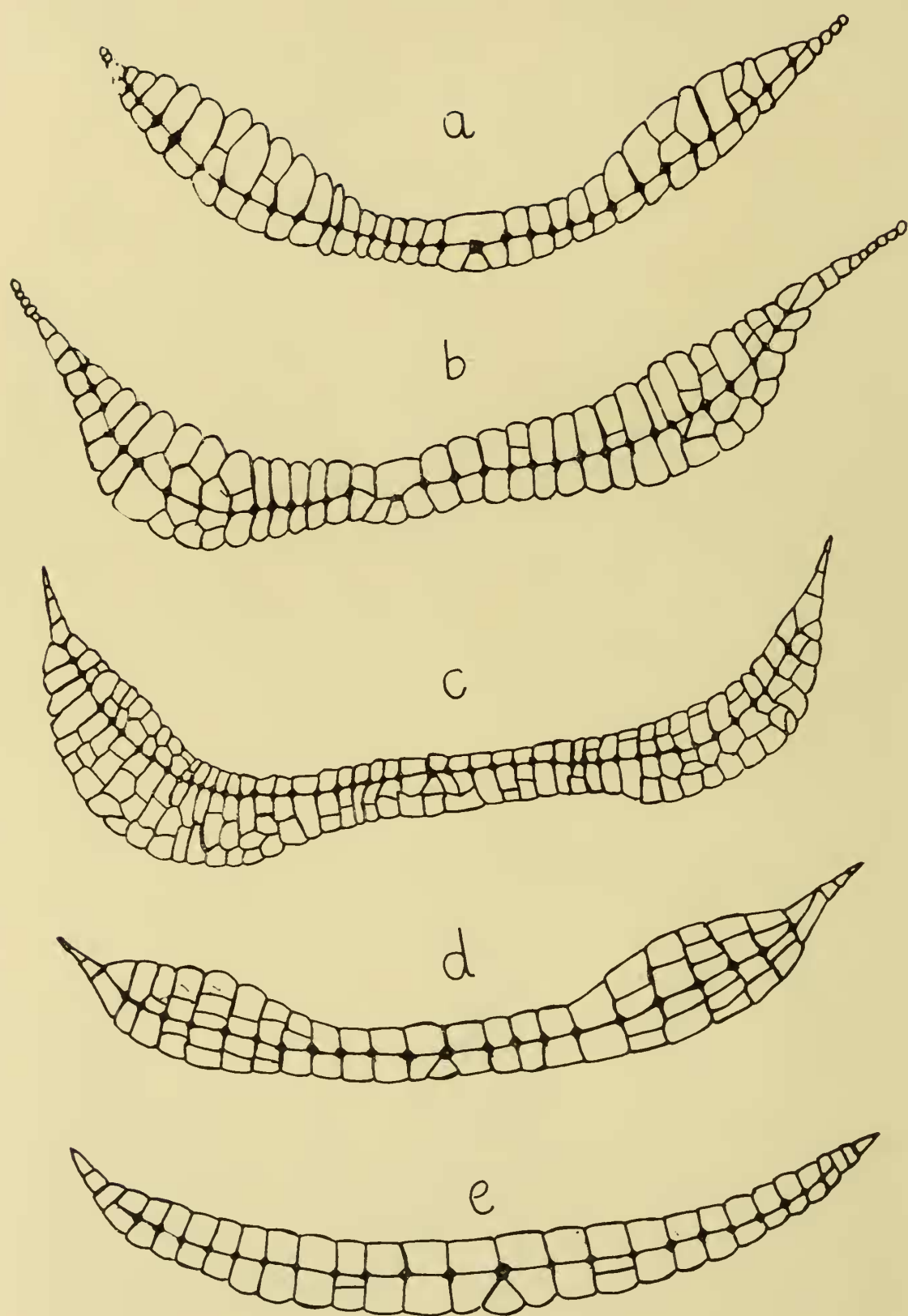


Figure 10. Transverse sections of leaves (x 60).
(a) *Leucobryum sanctum* (b) *L. bowringii* (c) *L. stenophyllum*
(d) *L. candidum* (e) *L. cyathifolium*.



Figure 11. *Leucobryum aduncum*; whole plant (x 2), capsule (x 6), leaf (x 13), t.s. leaf (x 140).

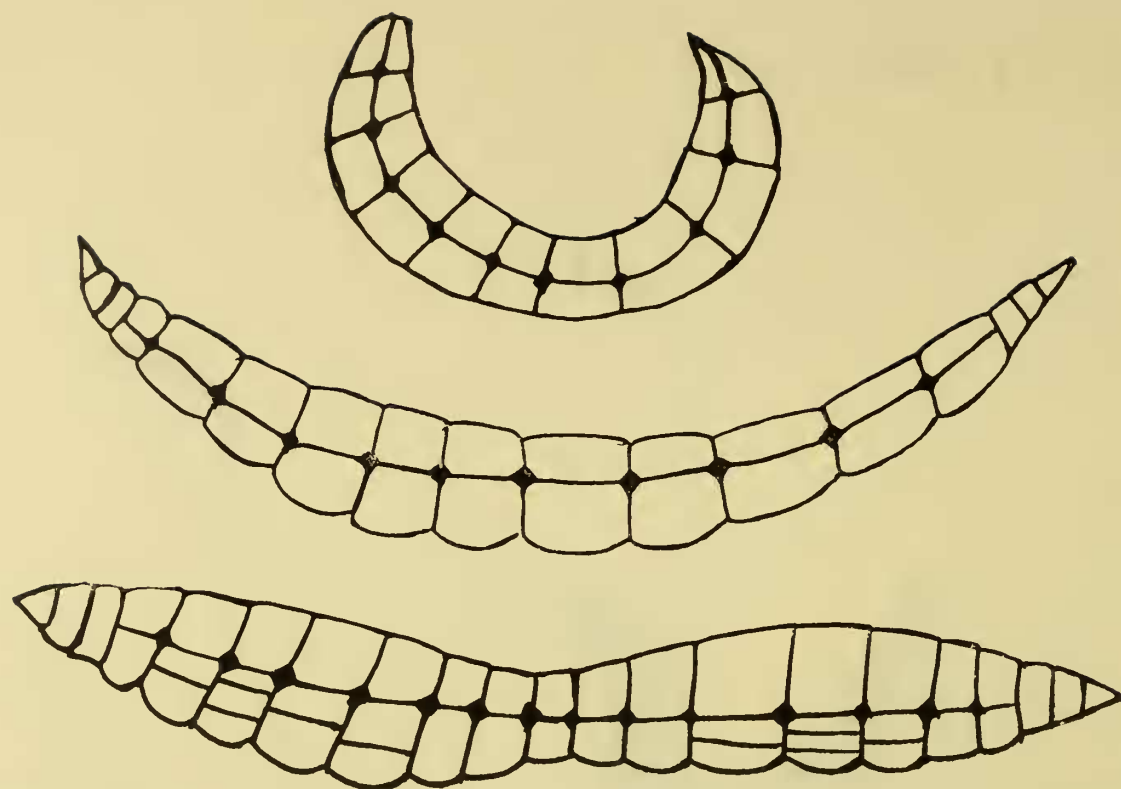


Figure 12. *Leucobryum microleucophanoides* t.s. leaves towards apex, middle and below (x 400).

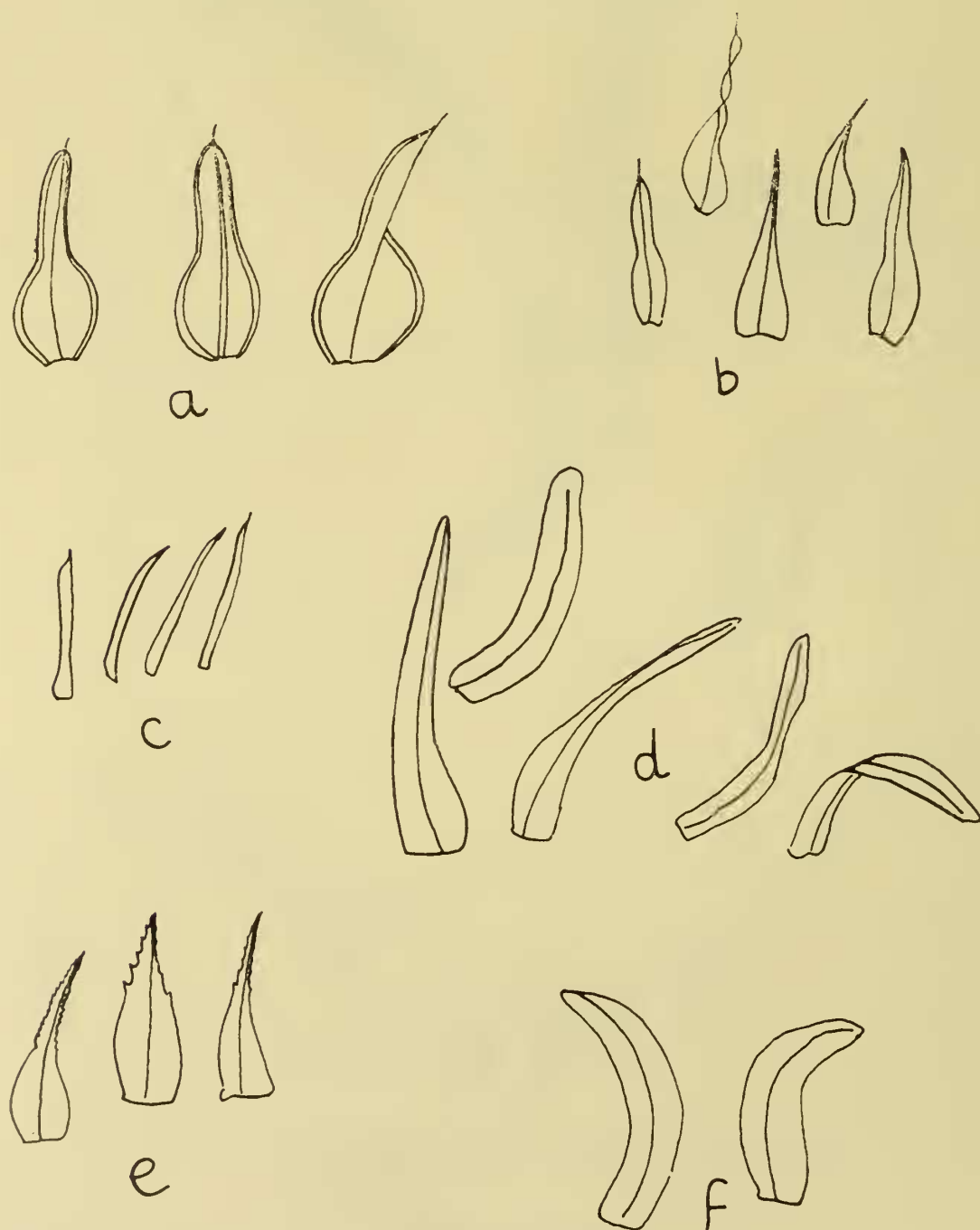


Figure 13. Leaves of species of *Leucophanes* (x 7).

(a) *L. candidum*.

(c) *L. albescens*.

(e) *L. sordidum*.

(b) *L. candidum* var. *densifolium*.

(d) *L. octoblepharoides*.

(f) *L. naumanii*.

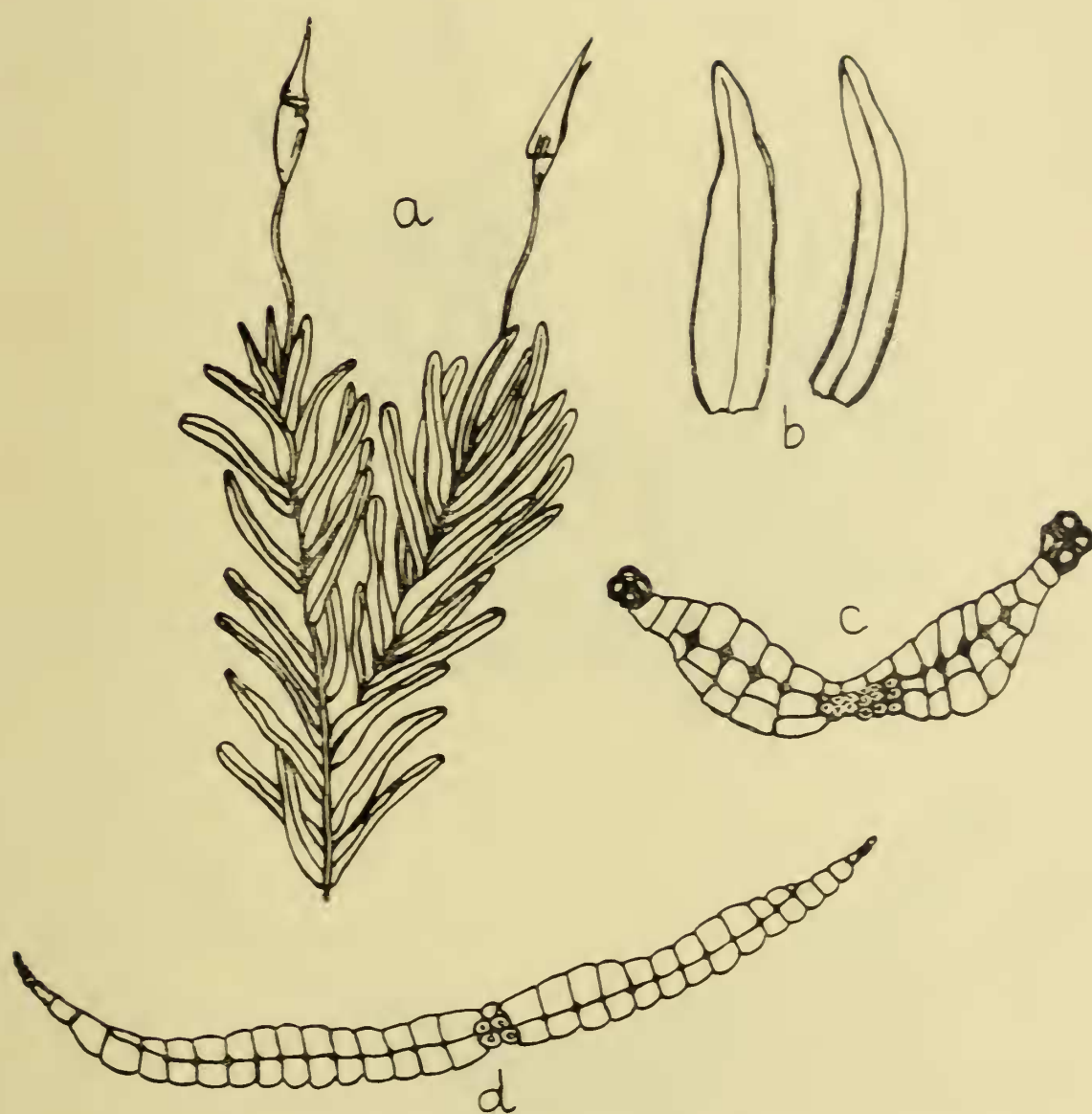


Figure 14. *Leucophanes octoblepharoides* (a) whole plant (x 3), (b) leaves (x 7), (c) t.s. mid-leaf (x 100), (d) *Leucophanes candidum* t.s. base of leaf (x 300).

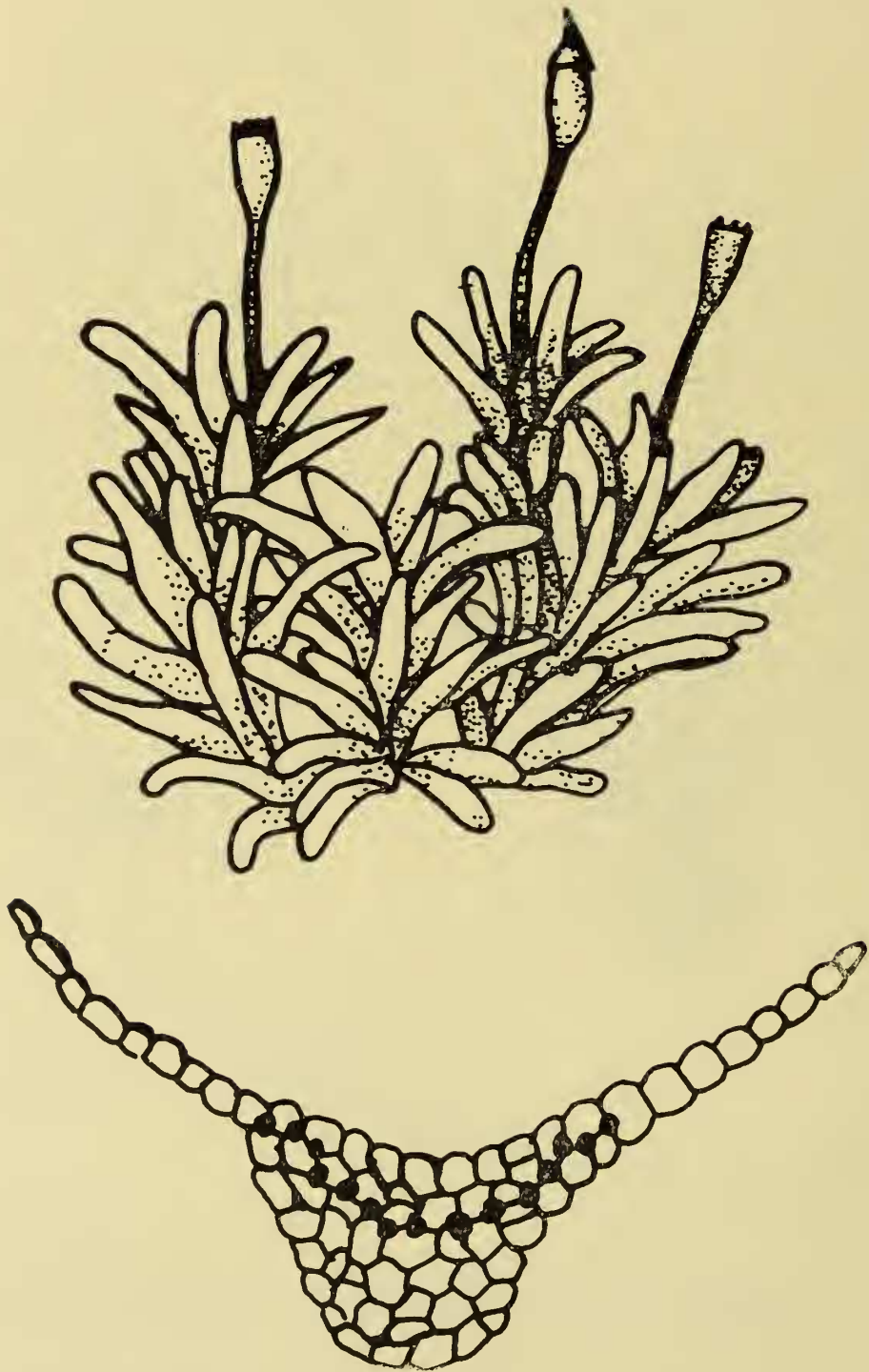


Figure 15. *Octoblepharum albidum* (above) whole plant (x 3), (below t.s. mid-leaf (x 400)).

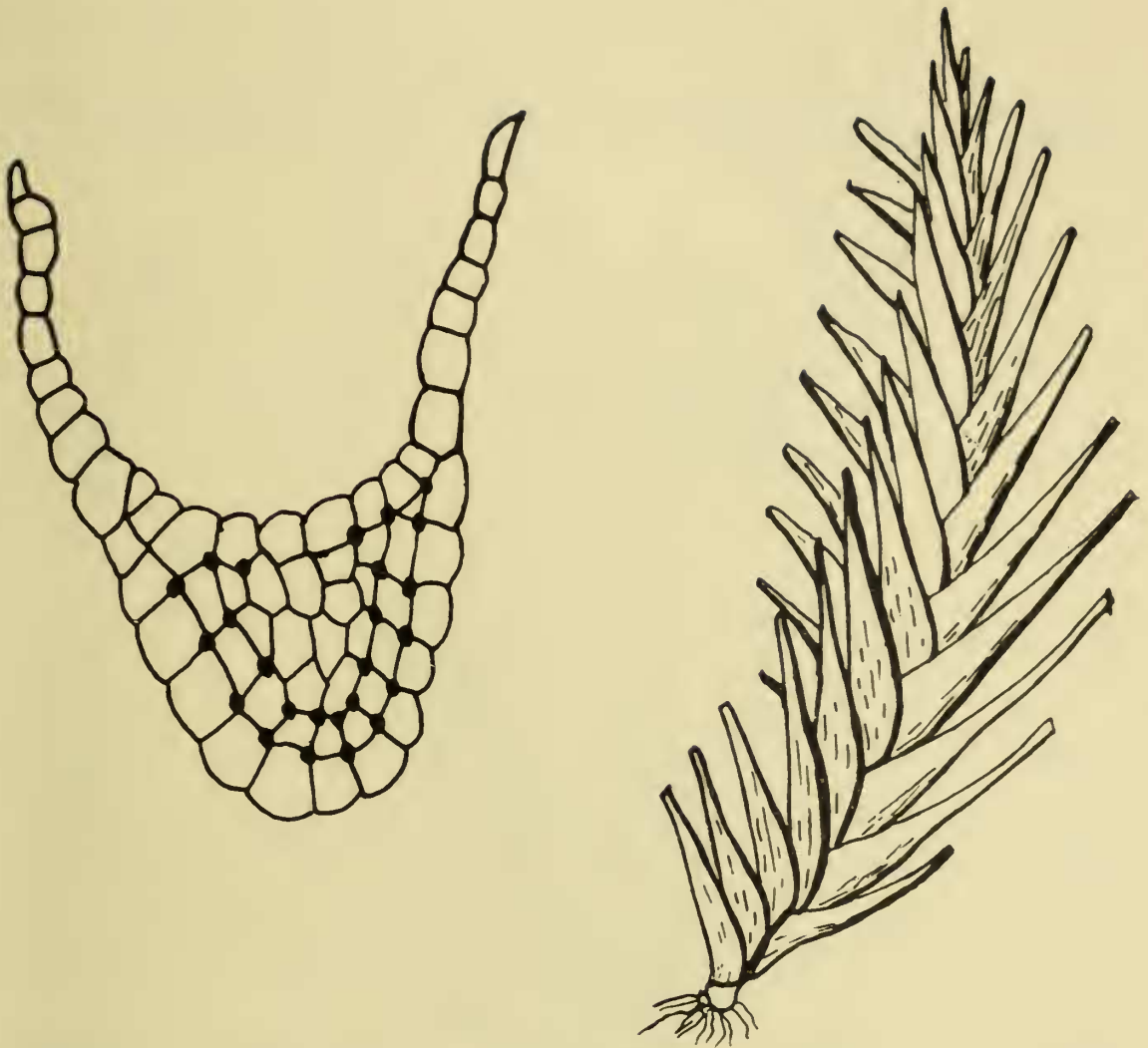


Figure 16. *Arthrocorpus schimperi* (left) T.s. thid-leaf (x 220): (right) single plant (x 3).

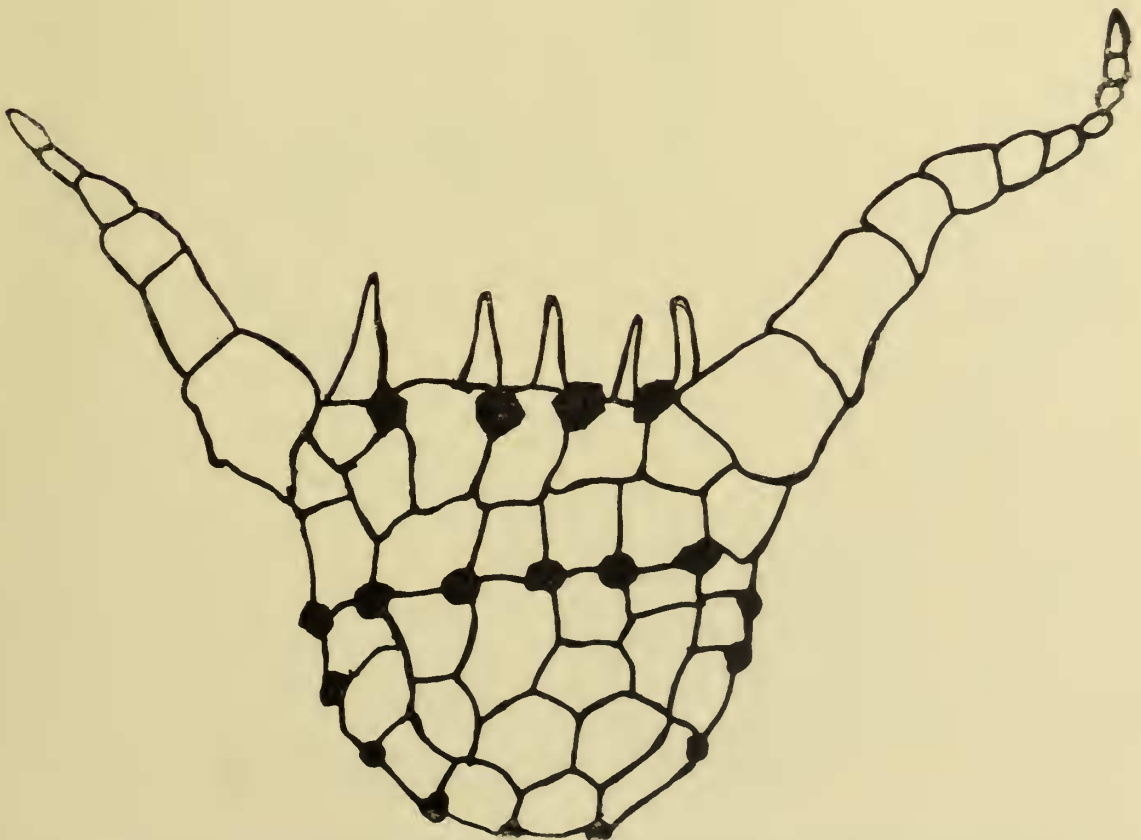


Figure 17. *Exodictyon sullivanii*, t.s. mid-leaf (x 100).

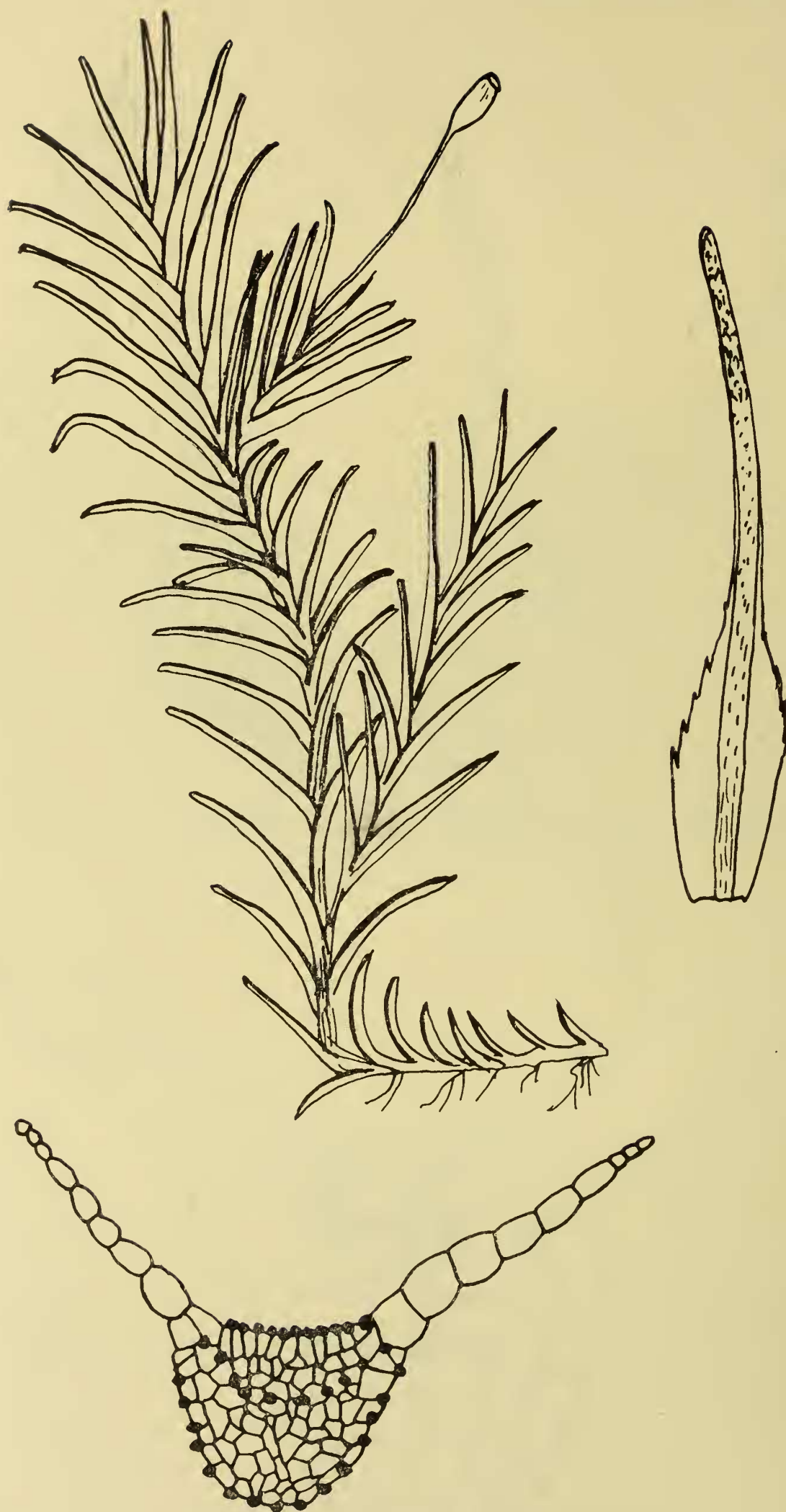


Figure 18. *Exodictyon blumii* (above) whole plant (x 6) and single leaf (x 20); (below) t.s. mid-leaf (x 200).